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Dickey-Lincoln School Lakes Project Environmental Impact Statement: Appendix A: Geology and Seismology (Supplement)

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ENVIRONMENTAL IMPACT STATEMENT

DICKEY-LINCOLN SCHOOL LAKES

APPENDIX A
GEOLOGY AND SEISMOLOGY
(SUPPLEMENT)

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

SEPTEMBER 1980

[redacted]

EVALUATION OF THE MINERAL POTENTIAL
UPPER ST. JOHN RIVER VALLEY
AROOSTOOK COUNTY, MAINE
MARCH, 1980

By:
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02154. Contract No. DACW 33-79-C-0085

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EVALUATION OF THE MINERAL POTENTIAL
UPPER ST. JOHN RIVER VALLEY
AROOSTOOK COUNTY, MAINE

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INTRODUCTION

In response to comments from public workshops and the draft EIS concerning the Dickey-Lincoln School Lakes Dam project, Governor Brennan on March 27, 1979 authorized the U.S. Army Corps of Engineers to contact the Department of Conservation in regard to mineral and other geological tasks to be carried out by the Maine Geological Survey. A proposal for the evaluation of the mineral potential in the upper St. John Valley, Dickey-Lincoln School Lakes Project, was prepared and submitted by Walter A. Anderson, State Geologist, Maine Geological Survey. The proposal was accepted on June 20, 1979 and contract No. DACW 33-79-C-0085 was awarded for $80,476 to carry out the project.

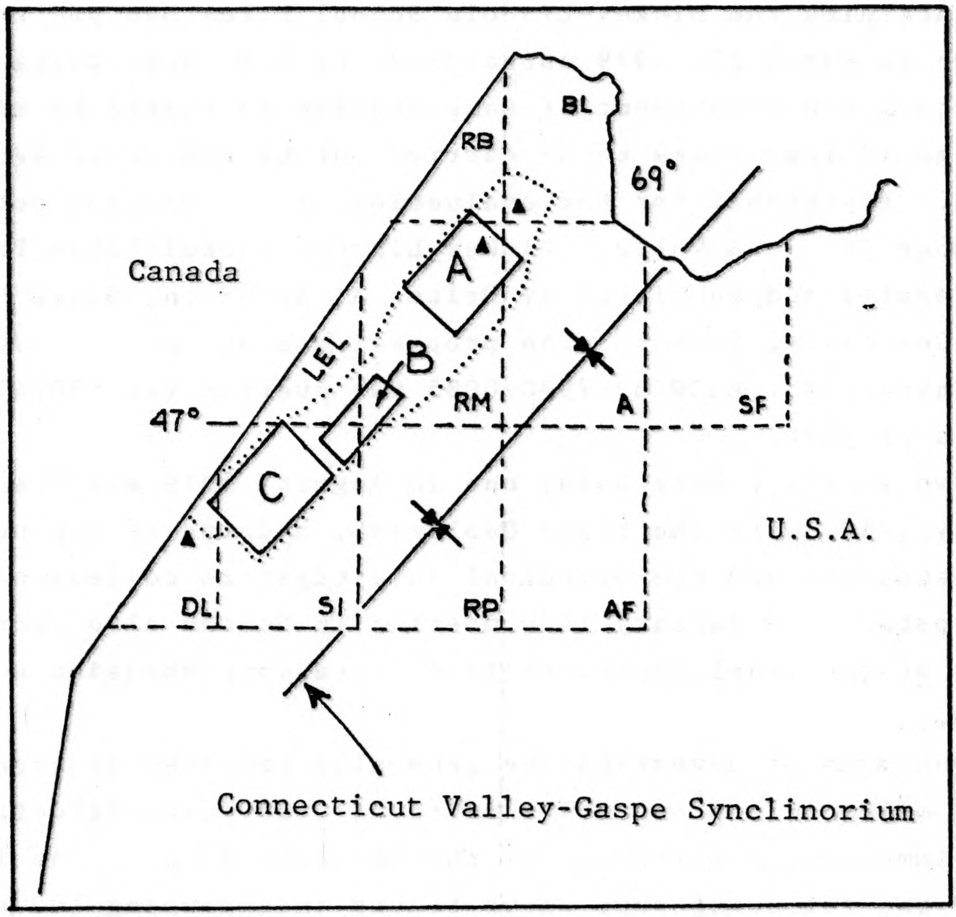
Two meetings were held, one in August, 1979 and the other in January, 1980, with the State Geologist, a Corps of Engineers' representative and the principal investigators to review and analyze field data. The January, 1980 meeting in Boston also addressed the format of the final report to facilitate comprehension and distribution.

The area of investigation generally embraces an area of 250 square miles in a prospective suite of Ordovician-Silurian volcanic rocks immediately northwest of the St. John River. The index map on the following page shows tracts encompassing 100 square miles which were designated for detailed work based on previous reconnaissance geologic mapping and their location within and adjacent to the impoundment area of the proposed Dickey-Lincoln School Lakes project.

The paucity of geologic information, difficult terrain, and one field season dictated the organization of three geologic field teams: (1) a geologic bedrock mapping team, (2) a surficial geologic mapping team, and (3) a geochemical and geophysical survey team.

The bedrock mapping team directed by Dr. David Roy of Boston College carried out a bedrock mapping task as an extension of the reconnaissance done in the early 60's by the U.S.G.S. Appendix A of this report contains a detailed record and map for this effort. The surficial geology mapping is the first such work done

INDEX MAP FOR MINERAL RESOURCE POTENTIAL
UPPER ST. JOHN RIVER VALLEY



Areas A, B, and C were areas of concentration; dotted line shows the extent of systematic coverage. The axis of the Connecticut Valley-Gaspe Synclinorium is located southeast of the area studied. The following 15-minute quadrangles are shown: A, Allagash; AF, Allagash Falls; BL, Beau Lake; DL, Depot Lake; LEL, Little East Lake; RB, Rocky Brook; RM, Rocky Mountain; RP, Round Pond; SI, Seven Islands; SF, St. Francis.

in any detail in the subject area. Appendix D contains a detailed text and maps on surficial geology. The geochemical and geophysical task involved the collection of stream sediment samples, the chemical analysis of the samples for heavy metals, and the development of geophysical profiles utilizing a proton magnetometer and a VLF-EM unit and a horizontal loop EM unit (See Appendices B & C).

The plan was prepared for a close working relationship between the evaluation teams and the immediate availability of geochemical and geophysical data to the geologic mapping team. Those samples determined in the field to be anomalously high in heavy metals by cold extractable procedures were sent to North American Laboratories where metal content determinations were made through: atomic absorption and spectrophotometry after hot acid digestion techniques.

RESULTS

The combined efforts of the evaluation team project generated the following results:

(1) Eight localities with anomalously high total heavy metal concentrations in stream samples have been found as a result of the geochemical survey (Summary and Appendix B). The areas are plotted on Plate A-1 to facilitate correlation with bedrock geology. None of the anomalies are below the proposed impoundment elevations of the lake.

(2) Heavy metal anomalies appear to be associated with the felsic volcanic rocks in the area.

(3) The bedrock geology effort generally confirmed the early reconnaissance work done in the early 60's by the U.S.G.S. and detailed stratigraphic and structural relationships, utilizing standard mapping techniques coupled with the geophysical data generated during the project (Summary and Appendix A).

(4) The surficial geology mapping task and report (Appendix D) describes a wide variety of glacial deposits which reveal a complex history of material transport and deposition. Caution therefore, should be exercised when interpreting mineral anomalies in glacial drifts (See Summary and Appendix D).

(5) The magnetometer was an effective tool in delineating igneous rock masses within the overall area of investigation (See Summary and Appendix C).

RECOMMENDATIONS

1. It is recommended that the private sector assess in detail the economic potential of the heavy metal anomalies identified by this project. The assessment will include detailed petrographic studies of the volcanic rock to assist in the interpretation of heavy metal anomalies.
2. Should the Dickey-Lincoln Project be implemented, it is recommended that advantage be taken of the construction activities to provide further detailed bedrock and surficial geologic mapping by the public or private sector. This study indicated the need for further bedrock mapping outside the Dickey-Lincoln Project area and should be focused on terrain northwest of the Rocky Mountain fault. Much of the Siluro-Devonian belt mapped by the U.S.G.S. may be largely pre-Late Silurian volcanic rocks with which currently known heavy metal anomalies seem to be associated. An important objective of future mapping should be further definition of pre-Depot Mountain units and their structural and stratigraphic relations.

   In addition, detailed surficial geologic mapping should focus on the complex depositional history of sequences of glacial, glacial lake, and alluvial sediments. Emphasis on stratigraphy and sediment transport will aid in the interpretation of heavy metal anomalies and ground water occurrance and movement.

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UPPER ST. JOHN RIVER VALLEY
BEDROCK GEOLOGY SUMMARY

Three distinctive belts of bedrock are important in Areas A, B, and C and in the connecting terranes (Plate A-1). The stratigraphic units are summarized in Table S-1 and are described fully in Appendix A.

The southeast belt consists of slate, graywacke, and quartz arenite of the Lower Devonian Seboomook Formation; the quartz arenite forms the Hafey Mountain Member of the formation. A medial belt consists of Silurian slatey limestone, calcareous slate, and andesitic volcanic rocks (Greenstone Member) comprising the Fivemile Brook Formation that is underlain conformably by the slate and graywacke of the Depot Mountain Formation of Ordovician and Silurian age. The medial belt is separated from the northwestern belt by the Rocky Mountain Fault in Areas A and B and by both the Rocky Mountain and Shields Branch Faults in Area C. The northwestern belt is composed of rocks of the Rocky Mountain Quartz Latite and the underlying Depot Mountain Formation in Area A. In Areas B and C the northwestern belt consists of sulfidic slate and quartzo-feldspathic graywacke of the Cambro-Ordovician Estcourt Road Sequence and rocks of the Depot Mountain Formation.

In Area C the three belts are truncated by a cross fault in the vicinity of Bruleau Pond (Plate A-1). To the southwest of this cross fault only the Depot Mountain Formation has been observed. That formation in this southwestern end of the area studied has a distinctive Aquagene Tuff Member of felsic composition.

Table S-1 -- Stratified Paleozoic Rocks in the Upper St. John River Basin, Maine

System/Series	Rock Units	Thickness (Meters)	Description
Lower Devonian	Seboomook Formation	2000 +	Gray slate and graywacke
	Hafey Mountain Member	0-800	Light gray siliceous quartz arenite
Upper Silurian	Fivemile Brook Formation	300-1800	Phyllitic calcareous slate; biomicritic limestone
	Greenstone Member	0-1000	Andesitic flows, sills, and pyroclastic rocks
Silurian	Rocky Mountain Quartz Latite	0-1000	Quartz latite; locally eutaxitic
Middle Ordovician-Lower Silurian	Depot Mountain Formation	2000 +	Dark slate and dark slate-chip rich graywacke
	Aquagene Tuff Member	900	Fine-grained felsic lithic-tuff and volcanogenic sharpstone conglomerate
Cambrian-Lower Ordovician	"Estcourt Road Sequence"	2000 +	Dark gray slate and phyllite with lesser thin-bedded quartz-rich fine-grained sandstone; complete disruption of bedding common

Volcanic Rocks: Of particular importance to the metal resource prospects of the region is the presence of both felsic (quartz latitic) and intermediate (andesitic) volcanic rocks, each apparently of Silurian age. The quartz latite of Rocky Mountain is a particularly impressive sequence which may be largely the result of subaerial eruption from a nearby vent or vents. The quartz latite appears to be younger than the Depot Mountain Formation and older than the Fivemile Brook Formation. Magnetic anomalies along magnetic traverses MT-8, MT-9, (Plate C-1), 0 and 10N (Plate C-4) together with a synclinal interpretation of the Rocky Mountain quartz-latite mass suggest that the lower half of the felsic sequence has a higher magnetic susceptibility than the upper part.

The intermediate volcanic rocks form a prominent member within the Fivemile Brook Formation in Areas B and C and appear to be younger than the felsic volcanic rocks. There are probably two lentils of these volcanic rocks in the Fivemile Brook Formation: a lower lentil is well expressed in both outcrops and by magnetic anomaly; the upper lentil is not as yet seen in outcrop but is mapped on the basis of its magnetic expression in Area B (Plate A-1). The andesites are responsible for magnetic anomalies on magnetic traverses MT-4, MT-5, (Plate C-2) and MT-7 near 150W (Plate C-3).

The Aquagene Tuff Member of the Depot Mountain Formation is associated with a magnetic anomaly in traverse MT-7 near 200W

(Plate C-3). Pyrite is abundant in the lithic felsic tuff that characterizes the member.

Slate: Slate is the predominant rock type in the region. Only the Silurian slate is appreciably calcareous. Slate of the Estcourt Road Sequence is commonly sulfidic and typically dark gray-to-black in color. The Seboomook Formation is comprised of slate that is generally medium-gray in color and weathers to brown. A prominent northeast trending and steeply dipping cleavage characterizes all slate of the region; this cleavage was formed during the Acadian Orogeny. No unambiguous earlier or later cleavage was observed during this study.

Faults: Three major faults are shown in Plate A-1. The Rocky Mountain and Shields Branch Faults are high angle strike faults. Neither fault has been seen in outcrop; their presence is inferred from the distributions of formational units. The ages of these faults are unknown but they are probably high angle reverse faults associated with the Acadian Orogeny of late Early Devonian age. A major un-named cross fault is inferred in Area C to account for the truncation of the Aquagene Tuff Member of the Depot Mountain Formation in the vicinity of Bruleau Pond and the termination of the Fivemile Brook Formation in the same area.

Bedrock Geology and Base Metal Anomalies: Eight localities with anomalously high total heavy metal concentrations in stream samples have been found as a result of geochemical survey

(Appendix B of this report). These areas are plotted on Plate A-1 to facilitate correlation with bedrock geology. Only the Chase Brook anomaly in Area A is attractive as a copper anomaly.

In Area A the Chase Brook and Whitney Brook anomalies are associated with the Depot Mountain Formation which is stratigraphically below the thick Rocky Mountain Quartz Latite. Similarly the two anomalies in the Pocwock Stream drainage are associated with rocks of the "Estcourt Road Sequence" that are stratigraphically below the quartz latite. These four anomalies may reflect stock-work sulfide deposits formed in these pre-latite units in and around feeder conduits for the Rocky Mountain Quartz Latite lavas. The association of massive and stock-work sulfide deposits with felsic volcanism is well established in Maine and New Brunswick deposits. Generally such deposits are in Ordovician volcanic and sedimentary rock sequences in/near felsic volcanic masses. For these reasons the four northern anomalies are particularly attractive and deserve further investigation.

Anomalies in Area B are clearly associated with the Greenstone Member of the Fivemile Brook Formation. These are heavy metal anomalies that are low in copper.

The anomalies of Area C are less clearly associated with volcanic rocks. Two of the anomalous stream segments are in a pre-Silurian unit and may represent mineralization of these rocks during Fivemile Brook volcanism. The third anomaly is underlain by Devonian slates. This third anomaly is found in a small drainage that crosses the Shields Branch Fault and has headwaters in terrane underlain by the Depot Mountain Formation.

It is interesting that no clear anomalies seem to be associated with the Aquagene Tuff Member of the Depot Mountain Formation in Area C since it is relatively abundant in pyrite. This is probably due to the fact that these tuffaceous rocks were deposited "cold" some distances from the volcanic vents.

MINERAL RESOURCE POTENTIAL
UPPER ST. JOHN RIVER VALLEY
GEOCHEMICAL SURVEY SUMMARY

On the basis of lithology, structure, and previous geochemical sampling, three local areas were delineated in the upper St. John River basin for detailed evaluation (Plate A-1). In these three areas, 1,369 stream sediment (89%) and soil (11%) samples were collected and analyzed for heavy metal content. All samples were analyzed in the field for cold-extractable heavy metals (cxHM) and cold-extractable copper (cxCu). Selected samples from both background and anomalous populations (139 samples, 707 metal determinations) were analyzed after hot acid digestion (4:2:1; HNO_3:HCl:$HClO_4$), by atomic absorption spectrophotometry.

Using a total population of 1,144 sediment samples, the mean cxHM value is 10.2 ppm. The metal value:frequency distribution graph showed that any sediment sample with a cxHM value of 20 ppm, or greater, was anomalous. Also, any cxCu value of 2 ppm, or greater, is to be considered significant. In the overall picture, the cxHM significance ranges appear to be valid in delineating areas of mineralization potential. However, in a detailed analysis of each area of sampling, the geochemical data may reflect the presence or absence of significant volumes of volcanic rock.

The reconnaissance geochemical survey delineated not less than eight anomalous areas which should be subjected to further investigation. These areas are generalized on Plate A-1 and the specific sites and cxHM value ranges are identified on Plates B-1 and B-2. Only one grid was established during the 1979 program, the Rocky Mountain grid (Plate C-3). Soil samples were collected and magnetometer and VLF-EM surveys conducted. Results of both geochemical and geophysical surveys on this grid were inconclusive.

Analytical data, both field and laboratory metal determinations, form part of the complete report submitted to the Maine Geological Survey.

MINERAL RESOURCE POTENTIAL
UPPER ST. JOHN RIVER VALLEY
GEOPHYSICAL SURVEY SUMMARY

During the 1979 field program in the upper St. John River basin, 36.6 line miles of geophysical surveying were completed. The vast majority of the geophysical work consisted of magnetometer surveys. Only the Rocky Mountain grid was covered with a VLF-EM survey as well as a magnetometer. Instruments used in these surveys were a McPhar Model GP-70 proton magnetometer and a Geonics Model EM-16 very-low-frequency electromagnetic unit (VLF-EM).

The study was based on the use of geophysical surveying to provide data to assist in geologic mapping. In a sedimentary rock terrane, a magnetometer traverse may cross diverse rock types (sandstone, shale, limestone) and there may not be any magnetic variation over the different rock types. Volcanic rocks in a sedimentary rock terrane are generally recognizable by a magnetic signature. The felsic volcanics (quartz latites) of the northern area (Plate A-1) and the andesitic belts of the central area (Plate A-1) appear to be magnetically well defined. Two smaller volcanic rock bodies were detected in the southern study area (Plate A-1).

The magnetometer was an effective tool in delineating igneous rock masses within the overall area of investigation, both the quartz latite lavas in the northern areas and the greenstone (andesites) in the central area. In such delineation, the magnetometer survey also outlines geologic environments within which sulfide bodies might be expected to occur.

MINERAL RESOURCE POTENTIAL
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SURFICIAL GEOLOGY SUMMARY

Surficial geology mapping along a belt parallel to and between the St. John River and the United States-Canadian border revealed a thin drift cover comprised of fourteen different units. Striation studies and stratigraphic relations indicate the deposition history, in five relative phases of the units as follows: (1) Strong eastward glacier flow eroded all previous surficial units and deposited a compact silty, often calcareous till. Glacier movement ceased and ice cover remained; (2) Glacier ice shifted flow direction to due north, incorporated upland drift, and deposited a thin unit presently expressed as a loose, oxidized, non-calcareous till. Glacial erosion imparted meter-sized stoss-and-lee forms on bedrock outcrops; (3) Gradual shift to northwest flow and the ice margin retreated into the study area. Ice flow strengths reduced as direction changed; (4) Fluctuating ice margin retreated southeast across the area with deposition of kames, kame terraces, eskers, moraines, and hummocky topography near ice margins and deposition of deltas and lacustrine sediments in glacier dammed lakes. Cold climatic conditions existed in the area; (5) After glacial ice recession fluvial processes reestablished drainage. Alluvium deposition in river valleys and soil development on surface units continues today. This complex history of material transport and deposition requires that these factors be considered when interpreting mineral anomalies in drift. (See Appendix D for details.)

APPENDIX A

EVALUATION OF THE MINERAL POTENTIAL
UPPER ST. JOHN RIVER VALLEY
AROOSTOOK COUNTY, MAINE

by

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Boston College
1980

Report Prepared for the Maine Geological Survey in connection with a Contract from the U. S. Corps of Engineers, New England Division

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INTRODUCTION

Detail reconnaissance and local detail bedrock mapping of portions of six 15-minute quadrangles in northwestern Maine were carried out during July and August of 1979. The purpose of the mapping was to refine the definitions and distributions of rock units established by Boudette and others (1967, 1976) within three areas that were selected as potentially containing metal deposits. These three areas are designated, from north to south, as A, B, and C and are shown in Figure A-1 and Plate A-1. The terrane between the areas was also mapped to determine as much as possible the along-strike continuity of the units; the extent of the systematic field work beyond Areas A, B, and C is shown in Figure A-1 and Plate A-1.

The belt of rocks studied lies along the northwestern flank of the Connecticut Valley-Gaspé Synclinorium which is cored by a broad belt of lower Devonian slate and graywacke loosely assigned to be Seboomook Formation (Figure A-1). The focus of the investigation reported here is, however, the pre-Devonian stratigraphy because base-metal deposits are considered to be more likely in rocks of that age in northern Maine.

The pre-Devonian in the area studied is along strike from Cambro-Ordovician sedimentary and volcanic rocks in Quebec to the southwest that are considered to have been formed in an early Paleozoic ocean basin that closed in the late Ordovician (St. Julien and Hubert, 1975). Ocean-basin rocks are especially

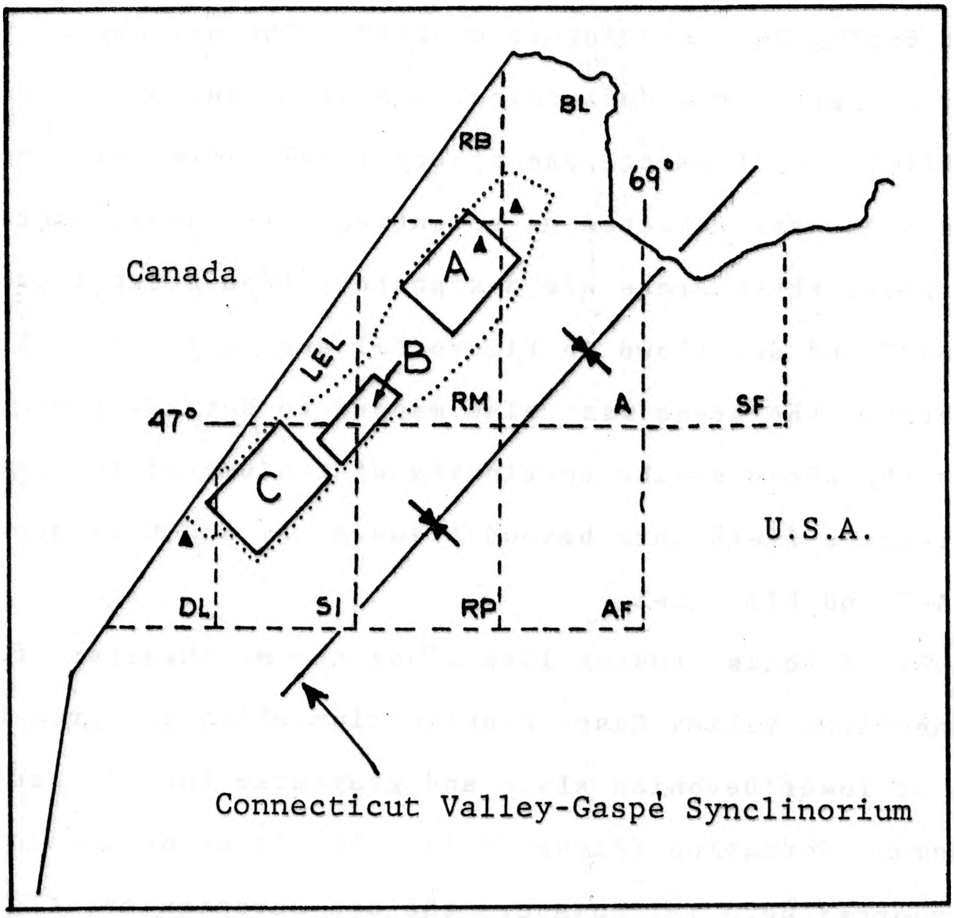

Figure A-1 Map of northwestern Maine showing the area mapped during this project. Areas A, B, and C were areas of concentration; dotted line shows the extent of systematic coverage. The axis of the Connecticut Valley-Gaspé Synclinorium is located just southeast of the area studied. The following 15- minute quadrangles are shown: A, Allagash; AF, Allagash Falls; BL, Beau Lake; DL, Depot Lake; LEL, Little East Lake; RB, Rocky Brook; RM, Rocky Mountain; RP, Round Pond; SI, Seven Islands; SF, St. Francis.

attractive for base-metal deposits and hence the importance of thoroughly examining terrane of such rocks in Maine. Of particular concern in this project are those portions of the area that will be affected directly or indirectly by the proposed Dicky-Lincoln empoundment.

Previous Work

The previous work in northwestern Maine is well summarized by Boudette and others (1976) who have themselves established the modern stratigraphic and structural understanding of the region. The work by Boudette and others (1967, 1976) was of a broadly reconnaissance character in which 4,250 km^2 were mapped in approximately two months of 1966. Their observations were limited to major lumber roads and streams but these observations gave them a more systematic bedrock coverage than previously possible. Boudette and others (1976) published a generalized geologic map at a scale of 1:250,000 but their 1967 open-file USGS report to the Corps of Engineers contains maps at 1:62,500 of each 15-minute quadrangle they examined. These large-scale maps were particularly useful in the present study.

Concurrently with the present bedrock study, geochemical and geophysical surveys were performed by North American Exploration, Inc. (Appendix B and C of this report) and the surficial geology was mapped by Mr. Thomas Lowell of the University of Maine at Orono (Appendix D of this report). The geophysical and surficial geology results proved useful in preparing Plate A-1.

STRATIGRAPHY

General

Table A-1 presents the stratigraphic section for northwestern Maine as proposed by Boudette and others (1976). Table A-2 shows the modification of their stratigraphy suggested by the present work. The major modifications are in the subdivision of the pre-Upper Silurian rocks and the elimination of the "Strata of Rocky Brook Terrane" and a unit of "gray slate and siltstone, graywacke and calcareous sandstone" (Silurian) as mappable units.

Most of the rocks of the "Five Mile Brook Sequence" of Boudette and others (1976) form a distinctive and easily mapped unit which has one prominently exposed volcanic horizon and a second horizon revealed by the magnetic data. It is recommended here that this unit be given formational status. The Quartz Latite unit of the "Five Mile Brook Sequence" is mapped separately in Plate A-1 because it has so far proven impossible to clearly associate it with other units. The rocks assigned to the Seboomook Formation by Boudette and others (1976) remain so. The "Hafey Mountain Sequence" is here considered to be a member of the Seboomook Formation.

The pre-Silurian is the most complicated and least well understood sequence of rocks. Boudette and others (1967, 1976) divided these rocks into three units: the "Lac Landry Sequence", the "Estcourt Road Sequence", and the "Depot Mountain Sequence".

Table A-1 —*Columnar section of the Paleozoic rocks in the upper St. John and Allagash River basins, Maine*

System	Series	Formations and members	Thickness (metres)	Remarks
Devonian	Middle (?)	Priestly Lake stock: Granodiorite.	----------------	Stock
Devonian	Lower	Seboomook Formation: Cyclically bedded slate and sandstone. Greenstone. Gray slate. Graywacke and gray slate.	[1] 5,000–7,000	Paleontologically dated.
Devonian and Silurian	Lower (Devonian) and Upper (Silurian).	"Hafey Mountain sequence" : Orthoquartzite and minor sandstone and siltstone.	0– 650	
Devonian or Silurian	Lower (Devonian) or Upper(?) (Silurian).	Strata of Rocky Brook terrane: Graywacke, gray slate, red and green arkose, color-variegated slate, calcareous quartzite and siltstone, and green volcaniclastic phyllite. Dark-gray cherty argillite.	[1] 2,000–4,000	Probable Silurian fossils.
Silurian	Upper	"Fivemile Brook sequence": Gray slate and siltstone, graywacke, and calcareous sandstone. Quartz latite. Greenstone. Calcareous siltstone and biostromal limestone.	[1] 1,100–1,600	Limestone dated subunits are mainly lenticular.
Ordovician	Middle	"Depot Mountain sequence": Polymictic conglomerate and black slate Black slate, graywacke, and sandstone	[1] 2,100–4,000	Paleontologically dated.
Ordovician and Cambrian.		"Estcourt Road sequence": Laminated black phyllite and gray quartzite.	1,600–2,500	2,000-m thickness assumed [1].
Paleozoic, undivided		"Lac Landry sequence": Orthoquartzite, gray slate, graywacke, and laminated sandstone.	[1] 800–[2] 1,600	
Total cumulative thickness (based upon assumed average thicknesses)			13,000	

[1] Assumed thickness where tectonic thickening is probable

[2] Only part of the sequence is present in area of this study.

From Boudette and others (1976)

Table A-2 -- Stratified Paleozoic Rocks in the Upper St. John River Basin, Maine

System/Series	Rock Units	Thickness (Meters)	Description
Lower Devonian	Seboomook Formation	2000 +	Gray slate and graywacke
	Hafey Mountain Member	0-800	Light gray siliceous quartz arenite
Upper Silurian	Fivemile Brook Formation	300-1800	Phyllitic calcareous slate; biomicritic limestone
	Greenstone Member	0-1000	Andesitic flows, sills, and pyroclastic rocks
Silurian	Rocky Mountain Quartz Latite	0-1000	Quartz latite; locally eutaxitic
Middle Ordovician-Lower Silurian	Depot Mountain Formation	2000 +	Dark slate and dark slate-chip rich graywacke
	Aquagene Tuff Member	900	Fine-grained felsic lithic-tuff and volcanogenic sharpstone conglomerate
Cambrian-Lower Ordovician	"Estcourt Road Sequence"	2000 +	Dark gray slate and phyllite with lesser thin-bedded quartz-rich fine-grained sandstone; complete disruption of bedding common

They refrained from establishing formal formations because of insufficient stratigraphic study of each sequence. The sequences are dominated by dark slate that is commonly sulfidic and in small outcrops (especially pavements) it is difficult to unambiguously distinguish one sequence from another.

In the present work, most of the rocks previously assigned to the "Depot Mountain Sequence" are placed in a newly defined formational unit, the Depot Mountain Formation. The Polymictic Conglomerate unit mapped by Boudette and others (1967, 1976) within the "Depot Mountain Sequence" was not found to be mappable in Area A as shown in their maps, but is mapped in Area C (Plate A-1) as the Aquagene Tuff Member of the Depot Mountain Formation. The Depot Mountain Formation is well-bedded, has distinctive lithic graywacke and polymictic conglomerate beds, and appears to have a single cleavage in the pelitic (slate) beds. The Depot Mountain Formation is lithologically almost identical with the Cabanno Formation of Lajoie, and others (1968) along strike to the northeast in Quebec.

Some rocks assigned previously to the "Depot Mountain Sequence" and some rocks previously indicated as part of the "Strata of Rocky Brook Terrane" (between Five Mile Brook and West Branch Pocwock Stream) have been reassigned to the "Estcourt Road Sequence". These outcrops have been reassigned because they do not have the well-bedded character and distinctive graywacke of the Depot Mountain Formation. All of the outcrops reassigned to the "Estcourt Road Sequence" were in the "Depot Mountain Sequence" or the "Strata of Rocky Brook Terrane" near the limits of the reconnaissance done by Boudette and others (1976). Most of the outcrops of the "Estcourt Road Sequence" as presently defined show a "disrupted formation" in which thin beds of quartzo-feldspathic siltstone or fine-grained sandstone and more massive quartzite beds have been tectonically disrupted and presently appear as fragments aligned parallel to cleavage. In some outcrops the disruption of original bedding is minimal and the unit is essentially as described by Boudette and others (1976) for the "Estcourt Road Sequence". The "Estcourt Road Sequence" is probably multiply deformed.

The "Lac Landry Sequence" was not examined in detail during this study because it is located well beyond the limits of the area studied. This sequence is described as containing massive quartzite beds, graywacke, laminated sandstone, and slate. Boudette and others (1976) do not give the relative abundances of the various rock types but their text and our brief examination of outcrops they assign to the unit suggest that slate is not the predominant exposed rock type. Distinguishing "Lac Landry" rocks from "Estcourt Road" rocks is difficult and the two units may be mixed locally in Plate A-1 as discussed in more detail below.

Estcourt Road Sequence

Lithology: As mapped in this study; the Estcourt Road Sequence consists of tectonically disrupted and locally thinly interlayered gray or black sulfidic slate and quartz-rich, light gray, commonly calcareous, laminated, micaceous siltstone and fine-grained sandstone. Dark-colored slate predominates. Locally interlayered green and red slate and thick-bedded siliceous quartz arenite (loosely "quartzite"[1]) are present.

Medium-to-dark gray phyllitic slate is the most common lithology. It typically shows a well-developed closely-spaced flow cleavage; the cleavage has the same generally northeast trend and steep dip that characterizes the Siluro-Devonian rocks and is therefore probably an Acadian fabric. No unambiguous earlier cleavage in the slate has been observed. The gray slate is most easily seen at locality 2776 (northwest Rocky Brook Quadrangle, Plate A-1). Dark-gray to black slate with variable sulfide mineralization as seen at locality 2782A (northwest Rocky Brook Quadrangle) and locality 2798 (northwest Seven Islands Quadrangle) is common. Field observations suggest pyrite to be the dominant sulfide mineral..

Red and green slate are best seen at locality 2739 (south-central Little East Lake Quadrangle) and appear to be minor. As yet no systematic distribution of red and green slate is apparent. Boudette and others (1976) included red and green slates they observed in the "Strata of the Rocky Brook Terrane" and considered them to be Siluro-Devonian in age. The assignment of these varigated slates to the "Estcourt Road Sequence" is based on their consistent association with the dark slate

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[1] Quartzite is a term properly applied to metamorphosed quartz-rich sandstones in which the original quartz-grain outlines have been obliterated due to complete recrystallization. Quartz arenite is a better term for similar appearing rocks in which the original quartz-grain outlines are well preserved; a siliceous quartz arenite is cemented by quartz (SiO_2) cement.

and thin-bedded siltstone (commonly with disrupted bedding) here considered to be absent in the known Siluro-Devonian of the region. Locality 2739 is in the "Strata of the Rocky Brook Terrane" belt of rocks as mapped by Boudette and others (1976).

The quartzose siltstone and fine-grained sandstone are interlayered on a centimeter scale with the gray and/or black slate described above. These coarser-grained beds are generally light gray in color, mica-parting laminated and cross-laminated, and variably calcareous. The calcareous varieties are more deeply weathered and show a brown "punky" weathering rind from which the carbonate has been removed. The siltstone/fine-grained sandstone beds are usually seen to be "dismembered" into segments a few centimeters in greatest dimension that are aligned parallel to the cleavage. "Delimbed" fold hinges with steep plunges are commonly observed; the disruption is therefore taken to be contemporaneous or slightly later than the formation of the fold hinges. The significance of the disruption in the formation is discussed more fully below.

Quartz arenite with silica cement is observed locally in the "Estcourt Road Sequence." The apparent lack of stratigraphic continuity of this resistent lithology along strike suggests that the original quartz arenite beds may also be disrupted. In some exposures quartz arenite "blocks" appear to be completely surrounded by slate. Quartz veins are common in the quartz arenite and rare in the surrounding slate. Lithic fragments and feldspar are abundant in some of the quartz arenite. The quartz arenite is well exposed at localities 2780 (northwest Rocky Mountain Quadrangle) and 2686 (West Central Rocky Mountain Quadrangle). At present it is not possible to lithologically differentiate quartz arenites of the "Estcourt Road Sequence" from those of the lower Devonian Hafey Mountain Member of the Seboomook Formation.

A few exposures of medium gray, greenish weathering, medium grained, micaceous, lithic arenite (or graywacke), as at locality 2767 (northwest Rocky Mountain Quadrangle), are assigned to the "Estcourt Road Sequence". This assignment is again based on these sandstones being associated with outcrops of structurally disrupted slate and siltstone typical of the sequence. Similar sandstones are described by Boudette and others (1976) and assigned to their "Strata of the Rocky Brook Terrane".

Thickness: The "Estcourt Road Sequence" is at least 2000 meters (6,000 feet) thick. Disruption of bedding and incomplete determination of its areal extent prevent precise measurement of the unit's thickness.

Age: The sequence is considered to be Cambrian-Early Ordovician in age due to its striking similarity to the Quebec, Armagh, and Caldwell groups along strike in Canada (Boudette, and others, 1976)

Depot Mountain Formation

Lithology: The name "Depot Mountain Formation" is herein assigned to a sequence of slate and graywacke that is largely equivalent to the "Depot Mountain Sequence" of Boudette and others (1976). The rock unit is distinctive enough, especially in graywacke lithology, to justify formational rank. In the absence of graywacke beds the unit is difficult to distinguish from the "Estcourt Road Sequence"; however, as presently mapped the Depot Mountain Formation does not show disrupted bedding. The name is derived from Depot Mountain in the Depot Lake Quadrangle where a partial section is well exposed. The most extensive section of the formation is found in Good Brook about four miles northeast of Depot Mountain (Plate A-1).

Slate in the Depot Mountain Formation is dark gray, fine grained, and well cleaved. The slate weathers to a rusty brown color. Quartz-rich siltstone laminae less than 1 cm. thick are abundant in the slate. Laminated slate appears to comprise approximately 80% of the section in Good Brook.

Interlayered with the slate are beds of medium- to dark-gray, medium- to coarse-grained lithic graywacke. A well-developed foliation is present in the graywacke. Compositionally[2] the graywacke consists predominantly of quartz, siltstone, and pelite[3] clasts with an interstitial matrix of muscovite, chlorite, and/or biotite. Quartz is present both as monocrystalline and polycrystalline grains. Siltstone clasts appear siliceous. Pelite clasts are presently recrystallized and foliated to slate

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[2] Based on hand specimen analysis.

[3] General term for an originally clay-rich (aluminous) rock that may now be shale, slate, phyllite, or schist.

and phyllite chips. These chips are commonly aligned parallel to the macroscopic foliation in the graywacke beds and it is possible they obtained their internal foliation during foliation development in the graywacke bed. Alternatively the chips could have been foliated prior to deposition and "simply" rotated into parallelism with the graywacke foliation. A predominantly sedimentary or low grade metasedimentary source seems likely for these graywacke beds.

Common fining upward (grading) of the grain size within the graywacke and current-produced erosional features on the bottoms of the graywacke beds are consistent with turbidity current deposition of the detrital grains. The graywacke beds range from a few centimeters to several meters in thickness.

Polymictic conglomerate beds from a few tens of centimeters to several meters in thickness are present in the Depot Mountain Formation. Conglomerate beds are typically composed of roundstone conglomerate that is clast-supported. Pebbles of sandstone, siltstone, slate/phyllite, chert (?), vein quartz, and felsic volcanic rocks predominate; typically meta-sedimentary rock types are most abundant. These conglomerate beds do not appear to be concentrated in a mappable unit as suggested by Boudette and others (1976).

Aquagene Tuff Member: The conglomerate unit mapped by Boudette and others from Depot Mountain to Bruleau Pond is monomictic and probably volcanogenic. At the summit of Depot Mountain (around the old fire tower site) an approximately

900 meter (2700 feet) section of green-gray weathering, fine-grained felsic tuff and monomictic, sharpstone, granule- to pebble conglomerate, that contains almost exclusively felsite fragments, is well exposed. Interlayered with these volcanoclastic rocks are thin beds of siliceous argillite and slate. The volcanoclastic rocks are evenly bedded and were probably deposited in "deep" water at some undetermined distance from the source eruption. Deposition was by either fallout through the water column or by secondary transport in turbidity currents. Stratigraphically below the volcanoclastic rocks are found slate and graywacke typical of the Depot Mountain Formation. These water-laid (aquagene) pyroclastic rocks have not been observed north of Bruleau Pond where they appear to terminate against a cross-fault (Plate A-1).

Contacts: The upper contact of the Depot Mountain Formation with the Silurian Fivemile Brook Formation is closely approached in road and stream exposures along the north branch of Twomile Brook. The contact has not actually been seen, but it appears to be conformable or disconformable; no features suggesting a fault contact or an angular unconformity are present.

The lower contact of the Depot Mountain Formation is not well understood at present. From approximately Fivemile Brook in the south to the vicinity of the East Branch of Pocwock Stream in the north, the Depot Mountain Formation is in contact with the "Estcourt Road Sequence" (Plate A-1). Boudette and others (1976) show a similar contact between the "Depot Mountain

Sequence" and the here abandoned "Strata of Rocky Brook Terrane" and interpret it as a fault (Jones Brook Fault). Presently this contact is interpreted as a fault between the Depot Mountain Formation and the "Estcourt Road Sequence" based on circumstantial evidence described below. The stratigraphic base of the Depot Mountain Formation has not as yet been defined.

Age: The Depot Mountain Formation is here considered to be of Ordovician-Silurian age based on a strong lithologic similarity to the Cabanno Formation in the Temiscouata Lake region of Quebec to the northeast (Lesperance, 1960; Lajoie and others, 1968). Boudette and others (1976) suggested this correlation as a possibility. As part of the present study, Cabanno rocks were examined in the Cabanno River valley and found to be identical to those of the Depot Mountain Formation. The upper Cabanno Formation is paleontologically dated as Early Silurian and can be shown to grade upward into younger Silurian units (Lajoie and others, 1968). In Canada the base of the Cabanno Formation is undated and is inferred to be unconformable on, or in fault contact with, the older Quebec Group. The Depot Mountain Formation is in an almost identical stratigraphic position with respect to older and younger rocks.

Boudette and others (1976) report the recovery of Middle Ordovician graptolites from a dark slate lens below the Aquagene Tuff Member of the present Depot Mountain Formation. The present writer was unable to duplicate the collection. If that fossil locality is taken at face value, the lower Depot Mountain Formation may be as old as Middle Ordovician.

Fivemile Brook Formation

Lithology: Here the name "Fivemile Brook Formation" is used to designate a distinctive sequence of sedimentary and volcanic rocks provisionally called the "Fivemile Brook Sequence" by Boudette and others (1976). The formation is named for Fivemile Brook, in Area B, along which almost continuous outcrop exposes the lower half of the unit. Exposures begin about 70 meters (200 feet) downstream from the Estcourt Road bridge; fossil locality F275 (Plate A-1) is in the section.

Sedimentary rocks of the Fivemile Brook Formation consist of medium gray, orange-buff weathering, very calcareous, slate and medium-gray biomicritic limestone. The slate is locally laced by calcite veins and commonly grades into cleaved argillaceous limestone. The biomicritic limestone contains abundant crinoidal debris and is present as discontinuous lenses or more irregular masses a few decimeters thick and usually a few meters parallel to bedding. The calcareous slate develops a "punky" rind up to two or three centimeters thick on pavement exposures. At fossil locality F275, coral (Favosites and Halysites) and stromatolite heads appear to be in growth position.

Greenstone Member: Andesitic igneous rocks form a 0-to-1000 meter (0-to-3000 feet) thick interval of sills, flows, and pyroclastic layers in the Fivemile Brook section.

This andesitic sequence can be mapped using outcrop and magnetic data as a member within the formation extending from just northeast of Area B to the Bruleau Pond Fault in Area C. In Area B the main part of the member is located in the lower part of the Fivemile Brook Formation but an upper lentil of andesitic (?) volcanics is suggested by magnetic anomalies in magnetic profiles MT-4 and MT-5 (Plate C-2 of this report for the profiles and Plate A-1 for the location of the profiles and the anomalies). No outcrops of the upper lentil of andesite have been seen and it appears that only the lower and thicker lentil persists south of Area B to the Priestly Bridge Road where it causes another magnetic anomaly (MT-7, Plate C-3). Neither lentil persists northward beyond magnetic profile MT-3.

The member has not been seen in Area A; however andesitic volcanic rocks are present along strike further northeast near Riviere-Bleue where they are in the same stratigraphic position between the Cabanno Formation and the Devonian Temiscouata Formation of Lajoie and others (1968).

Detailed study of these volcanic rocks has not been made but individual flows are discernable in the Fivemile Brook section and very fine pillow structures are present at locality 2843 in Area C.

Thickness: The thickness of the Fivemile Brook Formation is about 1800 meters at Fivemile Brook but thins to 300 meters near the East Branch of Pocwock Stream.

Age: Fossils from locality F275 near the base of the Fivemile Brook Formation are reported to indicate a Late

Silurian age by Boudette and others (1976). Correlations along strike in Canada support this conclusion. The sedimentary rocks of the Fivemile Brook Formation suggest shallow-water deposition preceding and succeeding andesitic volcanism.

Rocky Mountain Quartz Latite

Lithology: Felsic volcanic rocks, described as largely quartz latite, have been assigned to the Silurian by Boudette and others (1976) and included in their "Fivemile Brook Sequence". These rocks are herein mapped as a unit separate from the Fivemile Brook Formation. Boudette and others (1976) cite two occurences of these felsic rocks: the largest mass is at Rocky Mountain and a much smaller mass lies to the south and crosses the East Branch of Pocwock Stream. The present work has located a third mass to the north of Little Black River between the Hafey Brook and Rocky Brook drainages (Plate A-1).

The stratigraphic relations of these volcanic rocks to other units is unclear. At West Branch Pocwock Stream the felsic volcanics appear to be underlain by slate-graywacke that is compatible with the Depot Mountain Formation and overlain by calcareous slate and limestone typical of the Fivemile Brook Formation. At Rocky Mountain the felsites appear to be in contact with the Depot Mountain Formation below and to form a syncline in which younger rocks have apparently not been preserved. To the north of Rocky Mountain the felsite sequence seems to be stratigraphically above the

Depot Mountain Formation and may be in another syncline as suggested tentatively in Plate A-1.

The felsites could be a volcanic phase associated with the deposition of the Depot Mountain Formation or might be associated with Fivemile Brook sedimentation as suggested by Boudette and others (1976). The geologic map of Rocky Mountain given by Boudette and others (1976) shows the felsite as underlain by unnamed Silurian slate-graywacke and overlain by Silurian limestone followed by more slate-graywacke. In neither their large-scale 1967 maps or the small-scale 1976 map do Boudette and others show outcrops to justify the complicated stratigraphy depicted for Rocky Mountain. Increased road access and more woods traversing during the present work have produced no sedimentary rocks clearly interlayered or overlying the felsites of Rocky Mountain; several outcrops stratigraphically below the felsites along the western slopes of the mountain are lithologically typical of the Depot Mountain Formation. The felsites north of the Little Black River are interlayered with siliceous slate, quartz-rich crystal tuff (?), and volcanogenic (?) sandstones. These clastic rocks are not similar to those of the Fivemile Brook Formation and presently are considered more similar to rocks of the Depot Mountain Formation.

It is possible that the Rocky Mountain Quartz Latite is genetically related to the Aquagene Lithic Tuff Member of the

Depot Mountain Formation. The stratigraphic relationship between these two units can be enhanced with more detailed petrography.

Observations of the felsic volcanics during this study confirm the rock descriptions provided by Boudette and others (1976). The section of felsic volcanic rocks exposed on the west face of Rocky Mountain display an eutaxitic texture indicative of subaerial eruptions. Laminated and spherulitic felsites are also common in felsic volcanic sequence to the north of the Little Black River.

The quartz latite at Rocky Mountain produces magnetic anomalies in magnetic profiles MT-8 and MT-9 (Plate C-1) and in profiles 0 and 10N (Plate C-4). Profiles MT-8 and -9 each show two anomalies (Plate A-1). A synclinal interpretation of the latite at Rocky Mountain suggests that both of the anomalies are due to rocks in the lower half of the sequence that are repeated on opposite flanks of the syncline. The lower volcanic rocks of the sequence therefore have a higher magnetic susceptibility than those of the upper part of the unit.

Profile MT-1 (Plate C-1 and Plate A-1) crosses the latitic rocks north of the Little Black River and no magnetic anomaly is evident. If these more northern volcanic rocks are equivalent to similar rocks at Rocky Mountain they are best correlated with the low-susceptibility upper part of the Rocky Mountain sequence. The absence of anomalies in magnetic profile MT-2

(Plate C-1) suggests that the latitic masses on opposite sides of the Little Black River are not connected.

Thickness: If the synclinal structure shown in the Rocky Mountain Quartz Latite in Plate A-1 is correct, then approximately 1000 meters (3000 feet) of volcanic rock is preserved there. As little as 300 meters (900 feet) appears to be present at the East Branch of Pocwock Stream and north of the Little Black River.

Age: The Rocky Mountain Quartz Latite is probably Silurian in age, but may not be Late Silurian as suggested by Boudette and others (1976). A Devonian age is considered unlikely because of the presence of calcareous slate of the Fivemile Brook Formation overlying the unit at the East Branch of Pocwock Stream.

Seboomook Formation

Lithology: As mapped in this study, the Seboomook Formation is essentially as described by Boudette and others (1976). The name "Seboomook Formation" has become a generic term applied liberally to lower Devonian slate and graywacke found in northern and northwestern Maine. A broad belt of these rocks cuts through northwestern Maine but has been little studied. The Seboomook is a monotonous sequence and is apparently quite thick.

Following Boudette and others (1976) the Seboomook is divided basically into a lower graywacke-dominated phase and an upper slate-dominated phase. The dominance of graywacke or slate is based on outcrop frequency which is biased in favor of graywacke. The Hafey Mountain Member as mapped in this study is essentially the "Hafey Mountain Sequence" of Boudette and others (1976); the quartz arenite ("quartzite") of the member is clearly overlain and underlain by slate and graywacke typical of the Seboomook. Slate and graywacke on the west and northwest flanks of Hafey Mountain were assigned to the Silurian by Boudette and others and were considered difficult to distinguish from the Seboomook Formation; in Plate A-1 these rocks are in fact assigned to the Seboomook Formation.

Seboomook slate is medium- to dark-gray, flow cleaved, brown-weathering, and rarely calcareous. Finely cleaved, "papery" slates are present locally. Siltstone laminae are usually present but vary considerably in abundance. Pyrite porphyroblasts are common, but widely separated; the slate is not especially sulfidic and usually lacks the "rusty"-orange staining of slates beneath the Fivemile Brook Formation.

Graywacke of the Seboomook Formation is typically fine- to medium-grained, brown-weathering, crudely- to well-foliated, and generally lacking in internal lamination. Beds less than 30 cm thick appear to have more parallel lamination and cross-lamination than thicker beds. Fresh graywacke is medium gray. Quartz, feldspar, and muscovite are the principal detrital grains, but lithic graywacke showing abundant pelite and other sedimentary rock types are common.

Cleavage in both graywacke and slate beds is commonly parallel to bedding. Refraction of cleavage in graywacke is, however, usually seen.

The fault slice of Seboomook Formation in Area C is indicated by Boudette and others (1976) to consist of both the graywacke- and slate-rich phases. Since graywacke is typically subordinate to slate in the slice where seen during this study, the slice is assigned to the upper phase of the Seboomook.

The rocks of the lower phase can best be observed along roads to the south and southeast of Fox Pond in Area A. The upper phase can be seen along similar roads north of Bruleau Pond in Area C.

Lower Contact: The Seboomook Formation overlies the Fivemile Brook Formation along a contact that can be traced from near the East Branch of Pocwock Stream southwestward to the Priestly Bridge Road. This is the only candidate for the stratigraphic "base" of the Seboomook since elsewhere the formation is almost certainly in fault contact with older rocks. The contact is remarkably straight for about 40 km (25 miles). It is not seen but is most closely located in the vicinity of the East Branch of Pocwock Stream and where it crosses Chimenticook Stream. Boudette and others (1967) show a "sheared zone" where the contact has been placed in Plate A-1 of this report; on their 1976 map a "lineament" is shown crossing the stream there but the contact (in both of their reports) is placed upstream. The relocation of the contact in this study to the position of the "shear zone" might suggest that the contact is a fault. The "shear zone" consists of contorted Seboomook graywacke and slate that are laced with an unusual number of quartz veins; these rocks are seen in the first exposures downstream from the contact (Plate A-1). No brecciated, mylonitic, or closely-fractured rocks are visible in either the Seboomook or the outcrop upstream from the contact that is here assigned to the Fivemile Brook Formation.

The second argument in favor of a faulted contact involves the Hafey Mountain Member of the Seboomook. At Hafey Mountain the member is within the slate-graywacke Seboomook sequence at an unknown but apparently significant distance above the base of the formation. If all of the quartz arenite exposures along strike southwest from Hafey Mountain are part of the same but thinning sequence (as shown in Plate A-1), the member would appear to "descend" stratigraphically to the "basal" contact near the East Branch of Pocwock Stream. If the contact is a fault then one could view the "loss of section" below the member as due to structural removal.

At present the contact is mapped as stratigraphic, following Boudette and others (1967; 1976), in the region between Fox Pond and the East Branch of Pocwock Stream. It is certainly possible that the contact represents a major fault that is an extension, or splay, of the major structural break to the east of Rocky Mountain (Rocky Mountain Fault).

Age: No further basis for assessing the age and thickness of the Seboomook beyond that provided by Boudette and others (1976) is given by the present work. The Seboomook is considered to be Early Devonian in age.

REGIONAL STRATIGRAPHIC RELATIONSHIPS

The most intense effort in this study was directed at understanding the stratigraphy and structure of Areas A, B, and C in Plate A-1. The connecting terrane was examined because complete stratigraphic solutions are not possible in the three small areas alone and because it is intrinsically important to the coordinated bedrock, surficial, geochemical, and geophysical programs that along-strike connections be made. The stratigraphic interpretation is sufficient for the purpose of this investigation. The stratigraphy of the region southeast of the Rocky Mountain Fault is here considered to be well established. The present work has refined the work of Boudette and others (1976) but has not seriously revised it.

The geology northwest of the Rocky Mountain Fault is not well understood and locally it is now impossible to draw a geologic map. The results of the field study reported here, cast doubt on the presence of a continuous belt of Siluro-Devonian rocks northwest of the Rocky Mountain Fault as previously proposed. From the West Branch of Pocwock Stream to the southwest, all of the outcrops in the "Siluro-Devonian" belt seem to be pre-Silurian and assignable to the "Estcourt Road Sequence". To be sure, there are not as yet many exposures in much of that terrain but time and lack of road access limited what could be seen.

Within and to the northeast of the Pocwock drainage system the picture is in some ways worse. Along and to the north of Rocky Mountain Road (Plate A-1; cross-section A-A') and northwest of the Rocky Mountain Fault, outcrops of Depot Mountain, Fivemile Brook, and Seboomook (?) Formations are present. The outcrop that may be assignable to the Seboomook Formation is along Rocky Mountain Road just northwest of Chase Brook. There Boudette and others (1976) report shelly fauna of probable Silurian age from locality F-117 in "calcareous siltstone"[4]. Just to the northwest is an exposure of quartz arenite that is similar to the quartz arenite of the Hafey Mountain Member of the Seboomook. Thus in the upper reaches of Chase Brook a Siluro-Devonian succession does seem to be present and it is similar to that found southeast of the Rocky Mountain Fault. The Chase Brook succession also includes the Depot Mountain Formation which appears to underlie the Silurian as at Fivemile Brook.

It is not known how this Chase Brook sequence relates to the rocks north of the Little Black River or southwestward toward the Pocwock watershed. The available information is shown in Plate A-1 but no connections can now be made.

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[4] This outcrop could not be found in 1979.

STRUCTURE

Faults

Boudette and others (1967, 1976) have suggested that major "strike" faults are present in the area studied here. Strike-faults are faults that trend parallel to the structural "grain" of the region as defined by bedding and foliation. Such faults are difficult to establish because they may not cause mappable offsets. Large cross-faults generally offset formation contacts of "marker units" sufficiently to indicate their presence. In Plate A-1, a strike-fault interpretation is shown that is similar to that suggested by Boudette and others (1976); the presence of a large cross-fault is inferred for Area C, but many smaller scale faults indicated by Boudette and others (1976) are considered unnecessary and/or are not substantiated by field data.

Strike Faults: A major strike-fault system is shown in Plate A-1 that corresponds essentially to the Rocky Mountain Fault and Shields Branch Thrust proposed by Boudette and others (1976).[5] In this report the latter fault will be referred to as the "Shields Branch Fault". These faults conveniently explain rock relations along them but are not considered to represent unique structural solutions.

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[5] Their unpublished 1967 maps have a slightly different fault pattern, some different fault names, and differing inferences as to fault types than shown in the 1976 map. Only their 1976 interpretations will be used in comparisons given here.

In the vicinity of Rocky Mountain, a structural break is necessary between the Rocky Mountain Quartz Latite and the lower Seboomook Formation to the east. Bedding and foliation trends in the Seboomook maintain a consistent N35-40E trend whereas the Depot Mountain Formation contact with the quartz latite and stratification within the latite strike north-south. Between Rocky Mountain and Fox Pond to the south, the fault is inferred to be responsible for one of two photo lineaments (Air Photo 7-300[6]) near the pond.[7] From Fox Pond to the East Branch of Pocwock Stream, the fault appears to account for the truncation of the Silurian system and the erosionally resistant quartz latite mass.

Southwestward from the East Branch of Pocwock Stream the Rocky Mountain Fault is mapped as the contact between the "Estcourt Road Sequence" and the Depot Mountain Formation. A faulted relation is shown for the following reasons:

1. Much of the Depot Mountain Formation seems to be missing. In the Good Brook area the Depot Mountain Formation appears to form a much wider terrane and contains a 900 meter thick tuff member which is absent in the region northeast of Shields Branch.
2. No basal phase of the Depot Mountain Formation is present which might suggest that the contact is an conformity. The Depot Mountain Formation everywhere

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[6] The photo cited here is from a 1975 series provided by U.S. Corps of Engineers, New England Branch.

[7] Second lineament seems to correlate with quartz arenite assigned to the Hafey Mountain Member of the Seboomook Formation.

appears to be an off-shore deep-water formation.

3. Southwest of Five Mile Brook a sliver of Devonian rocks lies between the terranes of the "Estcourt Road Sequence" and the Depot Mountain Formation. It is very difficult with present information to account for the Devonian sliver without interpreting it as fault-bounded. The sliver appears to narrow to extinction near Fivemile Brook where the contact between the "Estcourt Road Sequence" and Depot Mountain Formation approaches the brook. The juxtaposition of the three units at Five Mile Brook is best explained by fault intersections as shown in Plate A-1.

The Rocky Mountain Fault is extended northeastward as suggested by Boudette and others (1976) but its location on Plate A-1 is slightly to the northwest of where they plotted it. As presently shown the Rocky Mountain Fault is positioned along the trend of the "Jones Brook Thrust" of Boudette and others. The Jones Brook Thrust is discussed below.

The displacement sense on each of these strike-faults is clear. For the Rocky Mountain Fault the northwest block is upthrown and for the Shields Branch Fault the southeast block is upthrown. It is unclear how the faults dip so it cannot be determined whether they are thrust or normal faults. These faults are probably essentially vertical since no secondary cleavage or closely-spaced joint set is present in rocks near them; shallow-dipping thrust faults seem unlikely. The magnitude of the displacements is unknown but is probably hundreds of meters (few thousand feet). The faults are of late Early Devonian age (Acadian Orogeny) or younger. If associated with the main compressional phase of the Acadian Orogeny these strike-faults are probably high-angle thrust faults.

The Jones Brook Fault of Boudette and others (1976) is here considered to be absent. Its presence in, and to the northeast, of Area C is considered unnecessary given the present outcrop control. However, as described above the stratigraphic and structural relations in the northwestern part of Area A are little understood and faults may be important.

Cross Faults: A major un-named cross-fault is proposed in Area C to explain the termination of the Aquagene Tuff Member of the Depot Mountain Formation east of Bruleau Pond and the southwestward termination of the Devonian sliver in the same area. The sense and magnitude of the displacement of this fault are unknown. Its extensions north and south of Bruleau Pond are similarly not determined.

Numerous cross-faults are shown by Boudette and others (1976), especially in the Rocky Mountain and Hafey Mountain areas. These faults are largely based on photo lineaments and are commonly shown as not offsetting contacts they cross. These faults are not needed in the structural interpretations given in Plate A-1. It is probable, however, that cross-faults are numerous, but it is not possible as yet to map them. The recommended assessment of the mineral anomalies in the project area may confirm their existance.

Folds

The sedimentary rocks of the area of this study have been tightly folded but it has generally proven difficult to map the folds in detail. Two synclinal folds are mapped in and north of Area A. Both of these synclines involve the Rocky Mountain Quartz Latite. It is possible, but considered unlikely, that they are portions of the same syncline. Evidence for structural closure of these folds is weak for the Rocky Mountain Syncline and non-existent for the inferred syncline north of the Little Black River. The low topography of the Little Black River valley together with sparse outcrops of Depot Mountain Formation in the river valley argue against a connection of the two folds. It is possible that the folds are terminated by faults rather than fold closures.

Minor fold hinges are seen locally, especially in the "Estcourt Road Sequence",but so far they are insufficient in number in the usually small exposures to work out patterns. The presence of a steeply dipping regional cleavage that is parallel-to-subparallel to bedding suggests that upright, tightly appressed, isoclinal folds characterize the Acadian deformation.

ASSOCIATIONS OF BASE METAL ANOMALIES WITH BEDROCK UNITS

Eight localities with anomalously high total heavy metal concentrations in stream samples have been found as a result of geochemical survey (Appendix B of this report). These areas are plotted on Plate A-1 to facilitate correlation with bedrock geology. Only the Chase Brook anomaly in Area A is attractive as a copper anomaly.

In Area A the Chase Brook and Whitney Brook anomalies are associated with the Depot Mountain Formation which is stratigraphically below the thick Rocky Mountain Quartz Latite. Similarly the two anomalies in the Pocwock Stream drainage are associated with rocks of the "Estcourt Road Sequence" that are stratigraphically below the quartz latite. These four anomalies may reflect stock-work sulfide deposits formed in these pre-latite units in and around feeder conduits for the Rocky Mountain Quartz Latite lavas. The association of massive and stock-work sulfide deposits with felsic volcanism is well established in Maine and New Brunswick deposits. Generally such deposits are in Ordovician volcanic and sedimentary rock sequences in/near felsic volcanic masses.

Anomalies in Area B are clearly associated with the Greenstone Member of the Fivemile Brook Formation. These are heavy metal anomalies that are low in copper.

The anomalies of Area C are less clearly associated with volcanic rocks. Two of the anomalous stream segments are in a pre-Silurian unit and may represent mineralization of these rocks during Fivemile Brook volcanism. The third anomaly is underlain by Devonian slates. This third anomaly is found in a small drainage that crosses the Shields Branch Fault and has headwaters in terrane underlain by the Depot Mountain Formation.

It is interesting that no clear anomalies seem to be associated with the Aquagene Tuff Member of the Depot Mountain Formation in Area C since it is relatively abundant in pyrite. This is probably due to the fact that these tuffaceous rocks were deposited "cold" some distances from the volcanic vents.

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APPENDIX B

EVALUATION OF THE MINERAL POTENTIAL UPPER ST. JOHN RIVER VALLEY AROOSTOOK COUNTY, MAINE

1979

GEOCHEMISTRY

December 1979

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INTRODUCTION

During the interval of June 11, 1979-September 23, 1979, North American Exploration, Inc. field personnel were participating in an evaluation of the mineral potential of the upper St. John River Valley, Aroostook County, Maine. These personnel included geologists, field technicians, and a chemist. The field work performed, geochemical and geophysical surveying, was guided by the specifications in a contract with the Maine Geological Survey. Certain preliminary results and a status report were presented to representatives of the Maine Geological Survey and the U. S. Corps of Engineers at a meeting in Augusta, Maine, on August 8, 1979, and in Boston, Massachusetts, on January 29, 1980. The 1979 program is now considered completed and the results are presented in this report.

APPENDIX B

GEOCHEMICAL SURVEY

On the basis of lithology, structure and previous geochemical sampling, three local areas were delineated in the upper St. John basin for detailed evaluation (Plate A-1). Area A, the northeasternmost, contains 35 square miles, Area B, central, 12 square miles, and Area C, southwesternmost, 40 square miles. In Areas A and B, the desired average sample density was 15 per square mile. The total number of sediment samples, including all three areas, was estimated at approximately 1,000.

In actuality, 505 samples (477 sediments, 28 soils) were collected in Area A, for an average sample density of 14.43 per square mile. Fourteen replicate sediment samples were also collected from Area A. In Area B, 192 samples (184 sediments, 8 soils) were collected, for an average sample density of 16 per square mile. Area C reconnaissance produced 419 samples (349 sediments, 70 soils), for an average sample density of 10.48 per square mile. An anomalous section of Area A was gridded and soils were sampled; it has been referred to as the Rocky Mountain Grid and it yielded 74 soils and one sediment sample. In the August meeting, it was decided that sampling should be extended north and south of Area A to the extent that time and funds would allow. To this end, 92 sediment samples were taken north and northeast of Area A (labeled AN) and 73 sediment samples collected south and southwest of Area A (labeled AS). The total number of samples (sediments, soils, and replicates) collected was 1,369, or 37% more than the guidelines projected in the contract proposal (Table B-1).

The original exploration plan submitted to the U. S. Corps of Engineers contained the mandate that geochemical data be made available to the senior mapping geologist on a day-to-day basis. To meet this contractural obligation, it was necessary that all samples be prepared and analyzed in the field, with a permanent reference split retained. All samples were air dried and sieved to minus 80 mesh and analyzed for cold-extractable heavy metals (cxHM) and cold-extractable copper (cxCu). Selected samples, from both the background and the anomalous populations, were sent to the NAE geochemical laboratory for hot acid (4:2:1; HNO_3:HCl:$HClO_4$)

digestion and determination for total copper, zinc, and lead by atomic absorption spectrophotometry. Some of the samples determined to be anomalous in one or more heavy metals were also analyzed for iron and manganese.

Using a total population of 1,144 sediment samples, the mean cxHM value is 10.2 ppm. Utilizing the metal value:frequency distribution graph, the following significance ranges for cxHM values were established:

0-15 ppm cxHM = background
16-19 ppm cxHM = threshold
20-20+ ppm cxHM = anomalous.

With a total population of 979 sediment samples from Areas A, B,and C, 941 samples, or 96.12 percent, ran 1 or <1 ppm cxCu. Thus, any cxCu value of 2 ppm, or greater, is to be considered significant.

In the overall picture, the cxHM significance ranges appear to be valid in delineating potentially mineralized areas. However, in a detailed analysis of each area of sampling, the geochemical data appear to reflect the presence or absence of significant volumes of volcanic rock. The geologic map by Boudette, Hatch,and Harwood (1976) was utilized in the following interpretations.

In Area A, mapped as containing sequences of quartz latite lava, the mean cxHM value is 11.33 ppm, with 10.07 percent of the total population being anomalous (20 ppm or greater).

In Area B, mapped as having a significant greenstone (metamorphosed andesite) contribution, the mean cxHM value is 9.63 ppm, and 8.15 percent of all samples are anomalous.

Area C is mapped as containing one, thin outcrop belt of greenstone (metamorphosed andesite), yet the mean cxHM value is 10.12 ppm and 10.34 percent of all samples are anomalous. This suggests the possibility of the presence of more volcanic rocks than has been recognized in the field.

In Area AN, in which no volcanic rocks have been recognized, the mean cxHM value drops to 6.09 ppm, and only 2.17 percent of the sample population are anomalous.

Within the undefined Area AS, the mean cxHM value is 10.38 ppm and 13.70 percent of the samples are anomalous. This general area includes a significant outcrop belt of quartz latite lava.

In Area A, 6.26 percent of all samples showed anomalous copper content, 1.09 percent in Area B, and 2.30 percent in Area C. None of the samples collected in Area AN contained even as much as 1 ppm cxCu, and only one sample in Area AS ran 2 ppm cxCu.

The results of the reconnaissance geochemical sampling program are shown on two plates(B-1, B-2) accompanying this report. These plates, at a scale of 2 inches equals one mile, show the sample location, sample number and pattern-coded cxHM values. Copper values are not shown and must be identified from data sheets (Certificates of Analysis).

In the northern area (Plate B-1), there are several prominent cxHM anomalies, among which the Whitney Brook drainage (T17 R12, and T18 R12) is most outstanding. Sediments from Whitney Brook carry threshold or anomalous cxHM values throughout nearly its entire length above its confluence with West Branch. This anomaly may reflect the belt of quartz latite lava, depicted as outcropping on the west side of Rocky Mountain. Only a few of these samples contain detectable cxCu. Chase Stream (T18 R12) is anomalous in both cxHM (up to 36 ppm) and cxCu (up to 8 ppm). The Chase Stream anomaly is an attractive exploration target. Although low in total heavy metals, the local area around sites A-148 - A-150 and A-194 - A-196 (T18 R12) constitutes one of the better cxCu anomalies discovered during the entire survey. In the undefined Area AS, the highest value cxHM anomaly in the overall basin (up to 66 ppm cxHM, but with no detectable cxCu) is located in T17 R13, on a small tributary to the west fork of the East Branch of Pocwock Stream. This anomaly, as well as Whitney Brook, may be related to an outcropping belt of quartz latite lava.

In the southern map sector (Plate B-2), there are two significant anomalies in Area B, both in the southeastern quarter of T16 R14. The anomaly expressed in sites B-001 through B-005 runs as high as 48 ppm cxHM, with only traces of copper. The second anomaly, found at sites B-130 - B-133 and B-171 - B-175, also displays values as high as 48 ppm cxHM, with only token cxCu confirmation.

In Area C, sites with anomalous heavy metal contents appear to be more scattered than in the other areas. The most discrete anomaly lies in the east-central part of T15 R15 (sample sites C-209 through C-214). In this small drainage, cxHM values range between 24 ppm and 32 ppm, with no cxCu confirmation. The anomalies associated with the two unnamed tributaries to Shields Branch (central and south-central T15 R15) are valid and should be investigated.

The reconnaissance geochemical survey delineated not less than eight anomalous areas which must be investigated further. These geochemical anomalies are explained in terms of the general bedrock geology in Appendix A.

During the reconnaissance sampling program, soil samples were taken, from place-to-place, where sediments were not available. On the sample location maps and Certificates of Analysis, soil-sample sites are identified with a suffix "S".

In an attempt to define the source of the copper anomaly detected at sample sites A-148 - A-150, T18 R12, a reconnaissance grid was established. Soil samples were collected at 100-foot stations on traverses 1,000 feet apart, for a total of 74 samples. Only three samples were anomalous in cxHM, one on each line over, or near, an out-of-phase VLF-EM crossover (Plate B-3). Only one of the soil samples showed detectable copper, 3 ppm cxCu at Station 2E on line 20N. The question of the cooper in sediment sites A-148 - A-150 remains unresolved and will require detailed evaluation as recommended in the report summary.

Included with this report are Certificates of Analysis for 139 samples, both sediments and soils, involving 707 individual metal determinations. These samples were subject to hot acid digestion, and metal concentrations determined by atomic absorption spectrophotometry.

TABLE B-1

NORTH AMERICAN EXPLORATION, INC.

GEOLOGY GEOPHYSICS GEOCHEMISTRY ENVIRONMENTAL STUDIES

November 6, 1979

Mr. Walter A. Anderson
State Geologist
Bureau of Geology
Augusta, Maine 04333

Re: St. John River Project

CERTIFICATE OF ANALYSIS
(ALL VALUES IN PARTS PER MILLION)

AREA "A"

Sample Number	cxHM	cxCu	Sample Number	cxHM	cxCu
9-SJR-A001	16	<1	9-SJR-A026	16	<1
-A002	24	<1	-A027	18	<1
-A003	12	<1	-A028	16	<1
-A004	10	<1	-A029	16	<1
-A005	10	<1	-A030	16	<1
-A006	10	<1	-A031	24	<1
-A007	10	<1	-A032	24	<1
-A008	10	<1	-A033	12	8
-A009	2	<1	-A034	24	<1
-A010	10	<1	-A035	28	4
-A011	14	<1	-A036	24	<1
-A012	10	<1	-A037	16	2
-A013	6	<1	-A038	6	<1
-A014	2	<1	-A039	10	<1
-A015	8	<1	-A040	14	<1
-A016	16	<1	-A041	10	<1
-A017	16	<1	-A042	14	<1
-A018	16	<1	-A043	6	<1
-A019	18	<1	-A044	6	1
-A020	10	<1	-A045	12	<1
-A021	24	<1	-A046	14	<1
-A022	14	<1	-A047	16	<1
-A023	10	<1	-A048	16	<1
-A024	22	<1	-A049	10	<1
-A025	16	<1	-A050	10	<1

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Sample Number	cxHM	cxCu	Sample Number	cxHM	cxCu
9-SJR-A051	8	<1	9-SJR-A101	8	<1
-A052	6	<1	-A102	4	<1
-A053	12	<1	-A103	6	<1
-A054	24	<1	-A104	8	<1
-A055	28	<1	-A105	6	<1
-A056	14	<1	-A106	6	<1
-A057	28	<1	-A107	10	<1
-A058	32	<1	-A108	4	<1
-A059	24	<1	-A109	4	<1
-A060	32	<1	-A110	6	<1
-A061	24	<1	-A111	10	<1
-A062	22	<1	-A112	8	<1
-A063	10	2	-A113	12	<1
-A064	16	1	-A114	10	<1
-A065	36	1	-A115	10	<1
-A066	20	<1	-A116	10	1
-A067	16	<1	-A117	10	<1
-A068	32	<1	-A118	16	<1
-A069	10	<1	-A119	12	<1
-A070	12	<1	-A120	14	<1
-A071	16	<1	-A121	10	<1
-A072	24	<1	-A122	14	<1
-A073	28	1	-A123	10	<1
-A074	20	2	-A124	6	<1
-A075	6	<1	-A125	10	<1
-A076	16	<1	-A126	10	1
-A077	24	1	-A127	10	<1
-A078	24	1	-A128	10	<1
-A079	16	2	-A129	16	1
-A080	18	1	-A130	10	1
-A081	16	<1	-A131	10	1
-A082	10	<1	-A132	10	<1
-A083	10	<1	-A133	12	<1
-A084	10	<1	-A134	8	<1
-A085	6	<1	-A135	10	<1
-A086	6	<1	-A136	16	<1
-A087	16	<1	-A137	12	<1
-A088	10	<1	-A138	10	<1
-A089	6	<1	-A139	10	<1
-A090	10	<1	-A140	8	<1
-A091	6	<1	-A141	10	<1
-A092	10	<1	-A142	8	<1
-A093	8	<1	-A143	8	<1
-A094	10	<1	-A144	6	<1
-A095	6	<1	-A145	6	<1
-A096	12	<1	-A146	6	<1
-A097	16	<1	-A147	6	<1
-A098	8	<1	-A148	10	12
-A099	10	<1	-A149	10	10
-A100	14	<1	-A150	8	2

Sample Number	cxHM	cxCu	Sample Number	cxHM	cxCu
9-SJR-A151	14	<1	9-SJR-A201	16	1
-A152	14	<1	-A202	10	<1
-A153	16	<1	-A203	10	<1
-A154	16	<1	-A204	14	<1
-A155	16	<1	-A205	6	<1
-A156	12	<1	-A206	10	<1
-A157	16	<1	-A207	10	<1
-A158	16	<1	-A208	6	<1
-A159	6	<1	-A209	10	<1
-A160	8	<1	-A210	6	<1
-A161	14	<1	-A211	14	<1
-A162	10	<1	-A212	8	<1
-A163	2	<1	-A213	6	<1
-A164	6	<1	-A214	2	<1
-A165	2	<1	-A215	10	<1
-A166	8	<1	-A216	6	<1
-A167	6	<1	-A217	16	1
-A168	6	<1	-A218	10	<1
-A169	6	<1	-A219	6	<1
-A170	6	<1	-A220	8	<1
-A171	10	<1	-A221	10	<1
-A172	8	<1	-A222	4	<1
-A173	6	<1	-A223	16	<1
-A174	16	<1	-A224	4	<1
-A175	6	<1	-A225	10	<1
-A176	10	<1	-A226	12	<1
-A177	2	<1	-A227	24	<1
-A178	6	<1	-A228	18	<1
-A179	6	<1	-A229	10	<1
-A180	4	<1	-A230	4	<1
-A181	4	<1	-A231	10	<1
-A182	4	<1	-A232	20	<1
-A183	10	<1	-A233	12	<1
-A184	10	<1	-A234	16	<1
-A185	6	<1	-A235	32	<1
-A186	2	<1	-A236	16	<1
-A187	8	<1	-A237	12	<1
-A188	16	<1	-A238	10	<1
-A189	32	6	-A239	10	<1
-A190	24	4	-A240	4	<1
-A191	36	4	-A241	14	<1
-A192	28	3	-A242	NS*	NS*
-A193	32	3	-A243	10	<1
-A194	16	10	-A244	10	<1
-A195	8	10	-A245	2	<1
-A196	12	4	-A246	10	<1
-A197	24	3	-A247	16	<1
-A198	10	<1	-A248	10	<1
-A199	10	<1	-A249	8	<1
-A200S	2	<1	-A250	10	<1

Sample Number	cxHM	cxCu	Sample Number	cxHM	cxCu
9-SJR-A251	6	<1	9-SJR-A301	10	<1
-A252	4	<1	-A302	10	<1
-A253	16	<1	-A303	10	<1
-A254	4	<1	-A304	8	<1
-A255	6	<1	-A305	2	<1
-A256	6	<1	-A306	20	<1
-A257	2	<1	-A307	22	<1
-A258	4	<1	-A308	6	<1
-A259	8	<1	-A309	6	<1
-A260	NS*	NS*	-A310	10	<1
-A261	12	<1	-A311	16	<1
-A262	10	<1	-A312	18	<1
-A263	16	<1	-A313	4	<1
-A264	16	<1	-A314	6	2
-A265	16	<1	-A315	12	<1
-A266	4	<1	-A316	16	<1
-A267	24	<1	-A317	16	<1
-A268	16	<1	-A318	6	<1
-A269	10	<1	-A319	10	<1
-A270	12	<1	-A320	4	<1
-A271	10	<1	-A321	14	<1
-A272	6	<1	-A322	16	<1
-A273	10	<1	-A323	4	<1
-A274	10	<1	-A324	10	3
-A275	16	<1	-A325	16	<1
-A276	10	<1	-A326	18	<1
-A277	16	<1	-A327	16	<1
-A278	16	<1	-A328	6	<1
-A279	6	<1	-A329	14	<1
-A280	12	<1	-A330	6	<1
-A281	10	<1	-A331	6	<1
-A282	8	3	-A332	8	<1
-A283	2	<1	-A333	10	<1
-A284	2	1	-A334	40	<1
-A285	6	<1	-A335	16	<1
-A286	12	<1	-A336	8	<1
-A287	8	<1	-A337	6	<1
-A288	16	<1	-A338	8	<1
-A289	2	<1	-A339	4	<1
-A290	10	<1	-A340	4	<1
-A291	6	<1	-A341	6	<1
-A292	2	<1	-A342	8	<1
-A293	6	<1	-A343	6	<1
-A294	8	<1	-A344	6	<1
-A295	12	<1	-A345	10	<1
-A296	6	<1	-A346	24	<1
-A297	6	<1	-A347	48	<1
-A298	6	<1	-A348	20	<1
-A299	12	<1	-A349	6	<1
-A300	6	<1	-A350	16	<1

Sample Number	cxHM	cxCu	Sample Number	cxHM	cxCu
9-SJR-A351	20	<1	9-SJR-A401	14	<1
-A352	10	<1	-A402	2	<1
-A353	12	<1	-A403	10	<1
-A354	44	<1	-A404	10	<1
-A355	6	<1	-A405	8	<1
-A356	2	<1	-A406	6	<1
-A357	10	<1	-A407	6	<1
-A358	6	<1	-A408	16	<1
-A359	24	<1	-A409	10	<1
-A360	10	<1	-A410	10	<1
-A361	10	<1	-A411	<1	<1
-A362	2	<1	-A412	4	<1
-A363	4	<1	-A413	6	<1
-A364	2	<1	-A414	6	<1
-A365	2	<1	-A415	6	<1
-A366	2	<1	-A416	2	<1
-A367	14	1	-A417	2	<1
-A368	6	2	-A418	10	<1
-A369	10	2	-A419	10	<1
-A370	12	4	-A420	10	<1
-A371	10	1	-A421	16	2
-A372	14	3	-A422	16	2
-A373	10	1	-A423	18	<1
-A374	10	1	-A424	18	1
-A375	16	3	-A425	8	<1
-A376	10	<1	-A426	10	<1
-A377	8	<1	-A427	10	<1
-A378	8	<1	-A428	6	<1
-A379	6	<1	-A429S	2	<1
-A380	12	<1	-A430S	<1	<1
-A381	4	<1	-A431	14	<1
-A382	8	<1	-A432S	<1	<1
-A383	6	3	-A433S	2	<1
-A384	6	<1	-A434S	<1	<1
-A385	6	<1	-A435S	2	<1
-A386	14	<1	-A436S	<1	<1
-A387	6	<1	-A437S	2	<1
-A388	2	<1	-A438S	<1	<1
-A389S	<1	<1	-A439S	2	<1
-A390	<1	<1	-A440S	2	<1
-A391	2	<1	-A441S	2	<1
-A392S	2	<1	-A442	2	<1
-A393	10	<1	-A443S	2	<1
-A394	32	<1	-A444S	<1	<1
-A395	2	<1	-A445S	<1	<1
-A396	10	<1	-A446S	2	<1
-A397	16	<1	-A447S	4	<1
-A398	16	<1	-A448S	2	<1
-A399	14	<1	-A449S	2	<1
-A400(This number not used)			-A450S	4	<1

Sample Number	cxHM	cxCu	Sample Number	cxHM	cxCu
9-SJR-A451S	6	<1	9-SJR-A507	6	<1
-A452S	2	<1	-A508	10	<1
-A453S	2	<1	-A033A	20	8
-A475	10	<1	-A034A	32	<1
-A476	10	<1	-A035A	36	4
-A477	14	<1	-A148A	6	6
-A478	24	<1	-A149A	8	14
-A479	10	<1	-A150A	10	10
-A480	16	<1	-A324A	10	8
-A481	12	<1	-A325A	16	1
-A501S	2	<1	-A327A	16	8
-A502S	4	<1	-A333A	10	1
-A503	10	<1	-A334A	24	<1
-A504	2	<1	-A335A	10	<1
-A505	6	<1	-A336A	6	<1
-A506	6	<1	-A383A	6	<1

AREA "B"

Sample Number	cxHM	cxCu	Sample Number	cxHM	cxCu
9-SJR-B001	24	<1	9-SJR-B026	2	<1
-B002	32	<1	-B027	6	<1
-B003	48	1	-B028	6	<1
-B004	32	1	-B029	4	<1
-B005	24	<1	-B030	6	<1
-B006	8	<1	-B031	4	<1
-B007	2	<1	-B032	2	<1
-B008	10	<1	-B033	6	<1
-B009	8	<1	-B034	10	<1
-B010	6	<1	-B035	6	<1
-B011	4	<1	-B036	2	<1
-B012	8	<1	-B037	8	<1
-B013	10	<1	-B038	6	<1
-B014	10	<1	-B039	8	<1
-B015	6	<1	-B040	8	<1
-B016	6	<1	-B041	10	<1
-B017	6	<1	-B042	10	<1
-B018	10	<1	-B043	2	<1
-B019	6	<1	-B044	6	<1
-B020	10	<1	-B045	6	<1
-B021	4	<1	-B046	10	<1
-B022	6	<1	-B047	8	<1
-B023	<1	<1	-B048	8	<1
-B024	2	<1	-B049	8	<1
-B025	2	<1	-B050	10	<1

Sample Number	cxHM	cxCu	Sample Number	cxHM	cxCu
9-SJR-B051	10	<1	9-SJR-B101	6	<1
-B052	10	<1	-B102	10	<1
-B053	18	<1	-B103	12	<1
-B054	18	<1	-B104	8	<1
-B055	10	<1	-B105	8	<1
-B056	8	<1	-B106	12	<1
-B057	10	<1	-B107	8	<1
-B058	12	<1	-B108	6	<1
-B059	4	<1	-B109	8	<1
-B060	6	<1	-B110	6	<1
-B061	4	<1	-B111	6	<1
-B062	6	<1	-B112	8	<1
-B063	10	<1	-B113	8	<1
-B064	8	<1	-B114	4	<1
-B065	6	<1	-B115	6	<1
-B066	6	<1	-B116	2	<1
-B067	4	<1	-B117	6	<1
-B068	6	<1	-B118	16	<1
-B069	8	<1	-B119	20	<1
-B070	10	<1	-B120	14	<1
-B071	16	<1	-B121	2	<1
-B072	8	<1	-B122	4	<1
-B073	6	<1	-B123	4	<1
-B074	6	<1	-B124	6	<1
-B075	6	<1	-B125	8	<1
-B076	8	<1	-B126	6	<1
-B077	10	<1	-B127	6	<1
-B078	8	<1	-B128	10	<1
-B079	10	<1	-B129	4	<1
-B080	6	<1	-B130	20	<1
-B081	6	<1	-B131	40	<1
-B082	10	<1	-B132	10	<1
-B083	14	<1	-B133	24	<1
-B084	16	<1	-B134	4	<1
-B085	12	<1	-B135	6	<1
-B086	8	<1	-B136	2	<1
-B087	10	<1	-B137	4	<1
-B088	8	<1	-B138	6	<1
-B089	10	<1	-B139	10	<1
-B090	10	<1	-B140	6	<1
-B091	10	<1	-B141	2	<1
-B092	2	<1	-B142	6	<1
-B093	12	<1	-B143	2	<1
-B094	4	<1	-B144	6	<1
-B095	18	<1	-B145	6	<1
-B096	40	1	-B146	8	<1
-B097	14	<1	-B147	2	<1
-B098	8	<1	-B148	2	<1
-B099	4	<1	-B149	6	<1
-B100	4	<1	-B150	6	<1

Sample Number	cxHM	cxCu	Sample Number	cxHM	cxCu
9-SJR-B151	12	<1	9-SJR-B172	48	<1
-B152	18	<1	-B173	32	2
-B153	10	<1	-B174	24	1
-B154	16	<1	-B175	14	<1
-B155	14	<1	-B176	16	<1
-B156	14	<1	-B177	16	<1
-B157	6	<1	-B178	10	<1
-B158	6	<1	-B179S	2	<1
-B159	6	<1	-B180S	2	<1
-B160	8	<1	-B181S	2	<1
-B161	8	<1	-B182S	2	<1
-B162	10	<1	-B183S	2	<1
-B163	16	<1	-B184S	2	<1
-B164	24	2	-B185S	<1	<1
-B165	10	<1	-B186S	<1	<1
-B166	10	<1	-B195	6	<1
-B167	8	<1	-B196	8	<1
-B168	14	<1	-B197	4	<1
-B169	8	<1	-B198	4	<1
-B170	10	<1	-B199	4	<1
-B171	24	<1	-B200	8	<1

AREA "C"

Sample Number	cxHM	cxCu	Sample Number	cxHM	cxCu
9-SJR-C001	14	<1	9-SJR-C021	20	<1
-C002	16	<1	-C022	NS*	NS*
-C003	24	<1	-C023	10	<1
-C004	16	<1	-C024	10	<1
-C005	16	<1	-C025	6	<1
-C006	16	<1	-C026	14	<1
-C007	16	<1	-C027	4	<1
-C008	16	<1	-C028	2	<1
-C009	20	<1	-C029	8	<1
-C010	10	<1	-C030	2	<1
-C011	16	<1	-C031	2	<1
-C012	4	<1	-C032	12	<1
-C013	4	<1	-C033	8	<1
-C014	4	<1	-C034	4	<1
-C015	8	2	-C035	10	<1
-C016	8	<1	-C036	10	<1
-C017	10	<1	-C037	10	<1
-C018	14	<1	-C038	4	<1
-C019	20	<1	-C039	8	<1
-C020	32	<1	-C040	6	<1

Sample Number	cxHM	cxCu	Sample Number	cxHM	cxCu
9-SJR-C041	14	<1	9-SJR-C091	<1	<1
-C042	10	<1	-C092	2	<1
-C043	10	<1	-C093	<1	<1
-C044	8	<1	-C094	<1	<1
-C045	8	<1	-C095	2	<1
-C046	4	<1	-C096	2	<1
-C047	2	<1	-C097	4	<1
-C048	2	<1	-C098	2	<1
-C049	2	<1	-C099	<1	<1
-C050	10	<1	-C100	2	<1
-C051	6	<1	-C101	20	<1
-C052	10	<1	-C102	20	<1
-C053	10	<1	-C103	16	<1
-C054	8	<1	-C104	16	<1
-C055	10	<1	-C105	18	<1
-C056	12	<1	-C106	10	<1
-C057	6	3	-C107	16	<1
-C058	10	<1	-C108	32	<1
-C059S	2	<1	-C109	22	<1
-C060S	2	<1	-C110	20	<1
-C061S	2	<1	-C111	14	<1
-C062S	<1	<1	-C112	10	<1
-C063	6	<1	-C113	6	<1
-C064	<1	<1	-C114	24	<1
-C065	6	3	-C115	16	<1
-C066S	16	<1	-C116	32	<1
-C067S	<1	<1	-C117	24	<1
-C068S	<1	<1	-C118	10	<1
-C069	6	<1	-C119	16	<1
-C070S	20	<1	-C120	14	<1
-C071S	2	<1	-C121	32	<1
-C072	2	<1	-C122	32	<1
-C073	<1	<1	-C123	16	<1
-C074	<1	<1	-C124	6	<1
-C075	<1	<1	-C125	10	<1
-C076	2	<1	-C126	10	<1
-C077	6	<1	-C127	6	<1
-C078	2	<1	-C128	6	<1
-C079	6	<1	-C129	4	<1
-C080	<1	<1	-C130	<1	<1
-C081	<1	<1	-C131	<1	<1
-C082	<1	<1	-C132	2	<1
-C083	<1	<1	-C133	4	<1
-C084	<1	<1	-C134	6	<1
-C085	2	<1	-C135	6	<1
-C086	2	<1	-C136	6	<1
-C087	2	<1	-C137	8	<1
-C088	2	<1	-C138	16	<1
-C089	<1	<1	-C139	6	<1
-C090	2	<1	-C140	6	<1

Sample Number	cxHM	cxCu	Sample Number	cxHM	cxCu
9-SJR-C141	6	<1	9-SJR-C191	6	<1
-C142	2	<1	-C192	2	<1
-C143	8	<1	-C193S	2	<1
-C144	4	<1	-C194S	<1	<1
-C145	10	<1	-C195S	2	<1
-C146	16	<1	-C196S	<1	<1
-C147	24	<1	-C197S	2	<1
-C148	14	<1	-C198	2	<1
-C149	14	<1	-C199	6	<1
-C150	10	<1	-C200	2	<1
-C151	6	<1	-C201	14	<1
-C152	14	<1	-C202	10	<1
-C153	18	<1	-C203	6	<1
-C154	6	<1	-C204	6	<1
-C155	16	<1	-C205	6	<1
-C156	10	<1	-C206	6	<1
-C157	6	<1	-C207	6	<1
-C158	4	<1	-C208	10	<1
-C159	8	<1	-C209	24	<1
-C160	6	<1	-C210	28	<1
-C161	14	<1	-C211	28	<1
-C162	10	<1	-C212	32	<1
-C163	10	<1	-C213	32	<1
-C164	10	<1	-C214	16	<1
-C165	16	<1	-C215	6	<1
-C166	18	<1	-C216	6	<1
-C167	20	<1	-C217	8	<1
-C168	8	<1	-C218	6	<1
-C169	6	<1	-C219	10	<1
-C170	2	<1	-C220	10	<1
-C171	4	<1	-C221	10	<1
-C172	2	<1	-C222	14	<1
-C173	2	<1	-C223	8	<1
-C174	6	<1	-C224	10	<1
-C175	8	<1	-C225	10	<1
-C176	14	<1	-C226	6	<1
-C177	10	<1	-C227	4	<1
-C178	10	<1	-C228	4	2
-C179	6	<1	-C229	10	<1
-C180	20	<1	-C230	10	<1
-C181	20	<1	-C231	10	<1
-C182	16	<1	-C232	14	<1
-C183	18	<1	-C233	16	<1
-C184	20	<1	-C234	16	2
-C185	16	<1	-C235	20	<1
-C186	16	<1	-C236	6	<1
-C187	20	<1	-C237	10	<1
-C188	4	<1	-C238	12	<1
-C189	4	<1	-C239	4	<1
-C190	6	<1	-C240	<1	<1

Sample Number	cxHM	cxCu	Sample Number	cxHM	cxCu
9-SJR-C241	18	<1	9-SJR-C291	16	<1
-C242	16	<1	-C292	16	<1
-C243	20	<1	-C293	10	<1
-C244	24	<1	-C294	10	<1
-C245	8	<1	-C295	10	<1
-C246	10	<1	-C296	40	<1
-C247	16	<1	-C297	10	<1
-C248	6	<1	-C298	14	<1
-C249	2	<1	-C299	10	<1
-C250	2	<1	-C300	16	<1
-C251	6	<1	-C301	8	<1
-C252	6	<1	-C302	16	<1
-C253	16	<1	-C303	10	<1
-C254	20	<1	-C304	8	<1
-C255	8	<1	-C305	6	<1
-C256	24	2	-C306	4	<1
-C257	16	<1	-C307	6	<1
-C258	10	<1	-C308	10	<1
-C259	18	<1	-C309	6	<1
-C260	24	<1	-C310	6	<1
-C261	10	<1	-C311	4	<1
-C262	14	<1	-C312	6	<1
-C263	6	<1	-C313	6	<1
-C264	24	2	-C314	2	<1
-C265	18	12	-C315	2	<1
-C266	10	1	-C316	12	<1
-C267	32	2	-C317	4	<1
-C268	8	<1	-C318	2	<1
-C269	12	<1	-C319	2	<1
-C270	12	<1	-C320	6	<1
-C271	14	<1	-C321S	2	<1
-C272	16	<1	-C322	4	<1
-C273	16	<1	-C323	6	<1
-C274	16	<1	-C324	8	<1
-C275	10	<1	-C325	8	<1
-C276	10	<1	-C326S	2	<1
-C277	10	<1	-C327	8	<1
-C278	26	<1	-C328S	<1	<1
-C279	16	<1	-C329S	<1	<1
-C280	10	<1	-C330S	2	<1
-C281	14	<1	-C331S	<1	<1
-C282	10	<1	-C332	2	<1
-C283	10	<1	-C333	8	<1
-C284	16	<1	-C334	10	<1
-C285	10	<1	-C335S	4	<1
-C286	10	<1	-C336S	<1	<1
-C287	10	<1	-C337S	<1	<1
-C288	10	<1	-C338S	<1	<1
-C289	10	<1	-C339	6	<1
-C290	10	<1	-C340	6	<1

Sample Number	cxHM	cxCu	Sample Number	cxHM	cxCu
9-SJR-C341	2	<1	9-SJR-C411	2	<1
-C342S	10	<1	-C412	2	<1
-C343S	<1	<1	-C413S	2	<1
-C344S	2	<1	-C414S	2	<1
-C345S	2	<1	-C415S	<1	<1
-C346S	10	<1	-C416S	2	<1
-C347	6	<1	-C417	10	<1
-C348	<1	<1	-C418S	<1	<1
-C349S	2	<1	-C419S	2	<1
-C350S	<1	<1	-C420S	<1	<1
-C351S	2	<1	-C421S	<1	<1
-C352S	2	<1	-C422S	<1	<1
-C353S	6	<1	-C423S	2	<1
-C354	<1	<1	-C424S	<1	<1
-C355S	4	<1	-C425S	<1	<1
-C356S	2	<1	-C426S	<1	<1
-C357S	<1	<1	-C427S	2	<1
-C358S	<1	<1	-C428S	2	<1
-C359S	2	<1	-C441	12	<1
-C360S	2	<1	-C442	16	<1
-C361S	2	<1	-C443	16	<1
-C362S	2	<1	-C444	16	<1
-C363S	2	<1	-C445	14	<1
-C364	14	<1	-C446	16	<1
-C365	4	<1	-C447	12	<1
-C366	4	<1	-C448S	2	<1
-C367	4	<1	-C449S	2	<1
-C368S	2	<1	-C450S	2	<1
-C369S	4	<1	-C451S	2	<1
-C370S	<1	<1	-C452S	10	<1
-C371S	<1	<1			
-C372	4	<1			
-C373	8	<1			
-C374	2	<1			
-C375	6	<1			
-C376	18	<1			
-C377S	4	<1			
-C378S	10	<1			
-C379	2	<1			
-C380S	2	<1			
-C401	6	<1			
-C402	8	<1			
-C403	6	<1			
-C404	12	<1			
-C405	14	<1			
-C406	16	<1			
-C407	18	<1			
-C408	14	<1			
-C409	4	<1			
-C410S	2	<1			

AREA "AN"

Sample Number	cxHM	cxCu	Sample Number	cxHM	cxCu
9-SJR-AN001	6	<1	9-SJR-AN046	10	<1
-AN002	8	<1	-AN047	4	<1
-AN003	<1	<1	-AN048	8	<1
-AN004	4	<1	-AN049	6	<1
-AN005	6	<1	-AN050	8	<1
-AN006	6	<1	-AN051	2	<1
-AN007	2	<1	-AN052	6	<1
-AN008	2	<1	-AN053	6	<1
-AN009	2	<1	-AN054	6	<1
-AN010	6	<1	-AN055	4	<1
-AN011	4	<1	-AN056	4	<1
-AN012	10	<1	-AN057	6	<1
-AN013	2	<1	-AN058	4	<1
-AN014	4	<1	-AN059	10	<1
-AN015	6	<1	-AN060	6	<1
-AN016	12	<1	-AN061	6	<1
-AN017	2	<1	-AN062	4	<1
-AN018	6	<1	-AN063	6	<1
-AN019	<1	<1	-AN064	2	<1
-AN020	4	<1	-AN065	6	<1
-AN021	2	<1	-AN066	4	<1
-AN022	6	<1	-AN067	16	<1
-AN023	4	<1	-AN068	2	<1
-AN024	<1	<1	-AN069	6	<1
-AN025	2	<1	-AN070	2	<1
-AN026	6	<1	-AN071	6	<1
-AN027	<1	<1	-AN072	4	<1
-AN028	<1	<1	-AN073	6	<1
-AN029	6	<1	-AN074	6	<1
-AN030	2	<1	-AN075	6	<1
-AN031	16	<1	-AN076	<1	<1
-AN032	14	<1	-AN077	8	<1
-AN033	2	<1	-AN078	2	<1
-AN034	6	<1	-AN079	6	<1
-AN035	24	<1	-AN080	4	<1
-AN036	32	<1	-AN081	8	<1
-AN037	2	<1	-AN082	4	<1
-AN038	14	<1	-AN083	6	<1
-AN039	8	<1	-AN084	6	<1
-AN040	2	<1	-AN085	2	<1
-AN041	6	<1	-AN086	10	<1
-AN042	16	<1	-AN087	6	<1
-AN043	4	<1	-AN088	6	<1
-AN044	2	<1	-AN089	14	<1
-AN045	8	<1	-AN090	6	<1

Sample Number	cxHM	cxCu	Sample Number	cxHM	cxCu
9-SJR-AN091	8	<1	9-SJR-AN092	4	<1

AREA "AS"

Sample Number	cxHM	cxCu	Sample Number	cxHM	cxCu
9-SJR-AS001	10	<1	9-SJR-AS041	20	<1
-AS002	2	<1	-AS042	18	<1
-AS003	10	<1	-AS043	16	<1
-AS004	2	<1	-AS044	14	<1
-AS005	10	<1	-AS045	16	<1
-AS006	4	<1	-AS046	26	<1
-AS007	10	<1	-AS047	14	<1
-AS008	24	<1	-AS048	8	<1
-AS009	24	<1	-AS049	6	<1
-AS010	12	<1	-AS050	12	<1
-AS011	12	<1	-AS051	8	<1
-AS012	8	<1	-AS052	10	<1
-AS013	6	<1	-AS053	10	<1
-AS014	14	<1	-AS054	10	<1
-AS015	4	<1	-AS055	6	<1
-AS016	2	<1	-AS056	14	<1
-AS017	6	<1	-AS057	10	<1
-AS018	4	<1	-AS058	6	<1
-AS019	4	<1	-AS059	2	<1
-AS020	8	<1	-AS060	6	2
-AS021	24	<1	-AS061	2	<1
-AS022	2	<1	-AS062	2	<1
-AS023	2	<1	-AS063	2	<1
-AS024	2	<1	-AS064	2	<1
-AS025	6	<1	-AS065	8	<1
-AS026	4	<1	-AS066	12	<1
-AS027	6	<1	-AS067	8	<1
-AS028	2	<1	-AS068	2	<1
-AS029	6	<1	-AS069	8	<1
-AS030	4	<1	-AS070	2	<1
-AS031	24	<1	-AS071	2	<1
-AS032	28	<1	-AS072	10	<1
-AS033	66	<1	-AS073	6	<1
-AS034	40	<1			
-AS035	12	<1			
-AS036	6	<1			
-AS037	6	<1			
-AS038	10	<1			
-AS039	10	<1			
-AS040	24	<1			

Rocky Mountain Grid

Sample Number	cxHM	cxCu
9-SJR-RM0+0	2	<1
-RM0+1E	10	<1
-RM0+2E	6	<1
-RM0+3E	6	<1
-RM0+4E	12	<1
-RM0+5E	<1	<1
-RM0+6E	6	<1
-RM0+7E	2	<1
-RM0+8E	2	<1
-RM0+9E	<1	<1
-RM0+10E	6	<1
-RM0+11E	2	<1
-RM0+12E	10	<1
-RM0+13E	10	<1
-RM0+14E	32	<1
-RM0+15E	6	<1
-RM0+16E	6	<1
-RM0+17E	2	<1
-RM0+18E	2	<1
-RM0+19E	2	<1
-RM0+20E	6	<1
-RM0+21E	4	<1
-RM0+22E	<1	<1
-RM0+23E	<1	<1
-RM10N+0	6	<1
-RM10N+1E	6	<1
-RM10N+2E	16	<1
-RM10N+3E	6	<1
-RM10N+4E	6	<1
-RM10N+5E	6	<1
-RM10N+6E	10	<1
-RM10N+7E	2	<1
-RM10N+8E	10	<1
-RM10N+9E	2	<1
-RM10N+10E	2	<1
-RM10N+11E	2	<1
-RM10N+12E	2	<1
-RM10N+13E	6	<1
-RM10N+14E	10	<1
-RM10N+15E	48	<1
-RM10N+16E	16	<1
-RM10N+17E	6	<1
-RM10N+18E	2	<1
-RM10N+19E	2	<1
-RM10N+20E	<1	<1
9-SJR-RM10N+21E	2	<1
-RM10N+22E	NS*	NS*
-RM10N+23E	NS*	NS*
-RM10N+24E	2	<1
-RM20N+0	6	<1
-RM20N+1E	16	<1
-RM20N+2E	6	3
-RM20N+3E	4	<1
-RM20N+4E	4	<1
-RM20N+5E	10	<1
-RM20N+6E	<1	<1
-RM20N+7E	6	<1
-RM20N+8E	6	<1
-RM20N+9E	6	<1
-RM20N+10E	2	<1
-RM20N+11E	4	<1
-RM20N+12E	16	<1
-RM20N+13E	6	<1
-RM20N+14E	4	<1
-RM20N+15E	6	<1
-RM20N+16E	6	<1
-RM20N+17E	16	<1
-RM20N+18E	22	<1
-RM20N+19E	16	<1
-RM20N+20E	2	<1
-RM20N+21E	14	<1
-RM20N+22E	2	<1
-RM20N+23E	2	<1
-RM20N+24E	2	<1
-RM20N+25E	2	<1
-RM20N+26E	2	<1
-RM20N+18E (Active Seep)	18	<1

*NS = No Sample

Respectfully submitted:

Michael J. Pasecznyk
Chemist

MJP:jaw

NORTH AMERICAN EXPLORATION, INC.

GEOLOGY GEOPHYSICS GEOCHEMISTRY ENVIRONMENTAL STUDIES

August 28, 1979

Re: Job No. 585

Maine Geological Survey
St. John River Project

Attention: R.S. Young

CERTIFICATE OF ANALYSIS

Forty-six (46) sediment samples analyzed as follows:

Sample No.	ppm Zn	ppm Cu	ppm Pb	ppm Ni	ppm Co	ppm Ag	ppm Mn	%Fe
B-002	231	7	35	37	22	.7	450	2.20
B-003	350	7	20	32	15	.7	700	2.45
B-004	150	7	10	35	17	.7	900	2.80
B-096	82	8	35	45	22	.7	6500	2.40
B-131	140	8	15	40	20	.7	2600	2.15
A-034A	230	7	20	25	10	1.0	2600	4.00
A-035A	210	7	22	17	55	.7	5100	3.25
A-148A	72	7	22	30	10	.5	650	2.20
A-149A	82	16	30	42	30	1.0	550	3.40
A-150A	90	24	42	67	20	.7	1650	2.60
A-324A	100	22	20	65	20	.7	400	4.85
A-325A	140	16	22	45	12	.5	1600	3.75
A-327A	120	20	30	82	7	.2	1350	2.50
A-189	260	20	20	47	12	.5	5400	4.75
A-190	260	9	25	45	17	.5	3450	4.60
A-191	230	10	25	40	22	.2	4050	3.90
A-192	210	10	20	47	15	.5	4200	3.85
A-193	200	10	22	37	17	1.0	2700	3.90
A-194	100	14	40	55	22	1.2	1100	2.45
A-195	90	26	52	35	10	1.2	1850	2.85
A-196	80	106	25	37	15	.7	650	2.45
A-197	180	71	27	35	15	.7	2850	3.40
A-368	80	16	20	55	25	.5	900	2.40
A-369	120	14	15	57	25	.5	550	2.70
A-370	100	13	22	55	22	.5	3000	4.65

POST OFFICE BOX 7584 CHARLOTTESVILLE, VIRGINIA 22906 TELEPHONE (804) 973-4328

Sample No.	ppm Zn	ppm Cu	ppm Pb	ppm Ni	ppm Co	ppm Ag	ppm Mn	%Fe
A-372	180	12	22	57	30	.5	1350	4.40
A-375	100	12	27	47	27	.7	900	2.10
A-383	70	20	22	57	30	.2	200	1.40
B-131A	270	12	22	55	22	.7	4450	2.90
B-172A	310	21	22	55	17	.5	2250	3.15
B-173	310	83	22	40	15	.5	1050	3.25
B-174	250	47	30	42	15	.5	3300	3.20
C-020	150	32	15	30	15	.5	5000	2.25
C-108	130	14	95	45	32	.2	3750	2.10
C-116	120	17	20	60	30	.5	1200	1.30
C-121	260	13	20	37	12	.5	7500	4.80
C-122	270	8	22	37	77	.7	6000	4.50
C-210	150	14	20	52	17	.5	3500	3.15
C-212	140	13	22	35	17	.5	3850	3.10
C-213	150	12	22	32	10	.2	6000	3.00
C-264	140	8	15	32	15	.5	11000	2.50
C-265	90	78	20	40	12	.7	700	2.20
C-266	70	10	10	27	7	.7	750	1.85
C-267	230	11	22	35	17	.5	20000	3.35
C-278	150	5	15	30	22	.7	2450	2.65
C-296	230	16	25	42	15	.7	3450	2.60

Respectfully submitted:

Donald W. Foss
Vice-President

DWF:jaw

NORTH AMERICAN EXPLORATION, INC.

GEOLOGY GEOPHYSICS GEOCHEMISTRY ENVIRONMENTAL STUDIES

August 28, 1979

Re: Job No. 586

Maine Geological Survey
St. John River Project

Attention: R.S. Young

CERTIFICATE OF ANALYSIS

Twelve (12) sediment samples analyzed as follows:

Sample No.	ppm Zn	ppm Cu	ppm Pb	ppm Ni	ppm Co	ppm Ag	ppm Mn	%Fe
A-091	90	9	22	32	12	.2	750	2.20
A-216	80	9	20	27	10	.2	750	2.45
A-317	110	8	22	37	15	.7	1100	2.30
A-418	130	9	15	47	15	.5	1000	2.95
B-072	310	6	10	45	15	.5	550	2.65
B-132	150	13	15	37	20	.7	1000	2.55
C-163	106	11	26	20	14	.2	1647	1.06
B-197	90	4	10	27	12	.2	500	2.05
C-041	100	8	12	32	12	.7	1250	2.10
C-145	90	6	12	35	15	.5	1500	2.15
C-175	70	3	10	25	10	.5	550	1.55
C-258	130	18	20	45	15	.2	2900	2.60

Respectfully submitted:

Donald W. Foss
Vice-President

DWF:jaw

POST OFFICE BOX 7584 CHARLOTTESVILLE, VIRGINIA 22906 TELEPHONE (804) 973-4328

NORTH AMERICAN EXPLORATION, INC.

GEOLOGY GEOPHYSICS GEOCHEMISTRY ENVIRONMENTAL STUDIES

N
E NAE W
S

October 5, 1979

Re: Job No. 635

Maine Geological Survey

Attention: R.S. Young

CERTIFICATE OF ANALYSIS

There are 81 samples analyzed as follows:

Sample Number	ppm Zn	ppm Cu	ppm Pb
9-SJR-B-164	150	12	15
9-SJR-B-171	138	15	12
9-SJR-C-003	115	5	20
9-SJR-C-009	115	7	17
9-SJR-C-019	78	10	17
9-SJR-C-021	108	7	25
9-SJR-C-070-S	55	5	15
9-SJR-C-101	100	5	17
9-SJR-C-102	95	5	17
9-SJR-C-109	150	5	25
9-SJR-C-110	120	10	20
9-SJR-C-114	58	7	15
9-SJR-C-117	125	10	22
9-SJR-C-147	125	7	15
9-SJR-C-167	58	5	17
9-SJR-C-180	108	7	15
9-SJR-C-181	100	5	17
9-SJR-C-184	118	10	20
9-SJR-C-187	100	10	17
9-SJR-C-211	100	5	22
9-SJR-C-235	85	5	12
9-SJR-C-243	125	7	17
9-SJR-C-244	150	7	25
9-SJR-C-254	75	10	20
9-SJR-C-256	113	12	37

POST OFFICE BOX 7584 CHARLOTTESVILLE, VIRGINIA 22906 TELEPHONE (804) 973-4328

Sample Number	ppm Zn	ppm Cu	ppm Pb
9-SJR-C-260	70	17	12
9-SJR-AN-035	70	10	17
9-SJR-AN-036	125	10	37
9-SJR-AS-008	210	7	20
9-SJR-AS-009	205	7	22
9-SJR-AS-021	120	5	25
9-SJR-AS-031	128	5	27
9-SJR-AS-032	190	10	35
9-SJR-AS-033	245	7	48
9-SJR-AS-034	180	7	32
9-SJR-AS-040	168	7	27
9-SJR-AS-041	158	10	25
9-SJR-AS-046	208	7	30
9-SJR-RM0+14E	138	15	25
9-SJR-RM10N+15E	148	7	22
9-SJR-RM20N+18E	105	12	27
9-SJR-A-021	130	10	34
9-SJR-A-024	130	6	13
9-SJR-A-031	148	11	18
9-SJR-A-032	138	11	17
9-SJR-A-036	150	9	18
9-SJR-A-054	144	6	17
9-SJR-A-055	150	6	17
9-SJR-A-057	166	6	14
9-SJR-A-058	172	8	16
9-SJR-A-059	135	7	15
9-SJR-A-060	182	8	19
9-SJR-A-061	154	8	18
9-SJR-A-062	136	5	14
9-SJR-A-065	200	9	18
9-SJR-A-066	152	5	11
9-SJR-A-068	182	8	16
9-SJR-A-072	174	10	17
9-SJR-A-073	132	10	16
9-SJR-A-074	150	9	17
9-SJR-A-077	138	8	15
9-SJR-A-078	136	9	18
9-SJR-A-227	107	10	15
9-SJR-A-232	109	15	25
9-SJR-A-235	184	10	48
9-SJR-A-267	112	5	13
9-SJR-A-306	164	16	31
9-SJR-A-307	68	7	19
9-SJR-A-334	128	6	22
9-SJR-A-346	114	8	26
9-SJR-A-347	224	7	27

Sample Number	ppm Zn	ppm Cu	ppm Pb
9-SJR-A-348	119	7	29
9-SJR-A-351	75	6	20
9-SJR-A-354	155	8	43
9-SJR-A-359	87	5	14
9-SJR-A-394	148	6	40
9-SJR-A-478	150	4	17
9-SJR-B-005	116	12	14
9-SJR-B-119	76	4	22
9-SJR-B-130	60	6	19
9-SJR-B-133	105	7	21

Respectfully submitted:

Donald W. Foss
Vice-President

DWF:jaw

APPENDIX C

EVALUATION OF THE MINERAL POTENTIAL UPPER ST. JOHN RIVER VALLEY AROOSTOOK COUNTY, MAINE

1979

GEOPHYSICS

December 1979
Revised March 1980

NORTH AMERICAN EXPLORATION, INC.
P. O. Box 7584
Charlottesville, Virginia 22906
(804) 973-4328

APPENDIX C

GEOPHYSICAL SURVEY

Under the terms of the MGS/NAE contract, NAE personnel conducted a series of magnetometer traverses throughout the study area as shown on Plate A-1. In addition, the Rocky Mountain grid was run with VLF-EM as well as a magnetometer. The total line miles of geophysical surveying is 36.6.

Instruments used in these surveys were a McPhar Model GP-70 proton magnetometer, reading total field, and a Geonics Model EM-16 very-low frequency electromagnetic unit (VLF-EM). Standard diurnal and day-to-day corrections were applied to magnetic data. No corrections were necessary for VLF-EM data.

Toward the close of the field season, none of the geochemical anomalies, except the Rocky Mountain grid area, had been sufficiently well defined geologically or geochemically, to justify establishing a grid for geophysical surveying. In light of this restriction, representatives of COE, MGS, and NAE elected to use the major part of available geophysical surveying time to provide data to assist in geological mapping. The general location, orientation, and length of the magnetometer traverses were selected by the geologic mapping team. It should be kept in mind, when viewing the magnetic profiles, that it is the magnetic susceptibility of near-surface rocks that has the greatest effect on the magnetometer response. Thus, a magnetometer traverse may cross diverse rock types (sandstone, shale, limestone) and there may not be any magnetic variation over the various rock types. Volcanic rocks in a sedimentary terrane are generally recognizable by a magnetic signature.

AREA "A", MAGNETOMETER TRAVERSE -1 (MT-1): There are no obviously significant magnetic variations on this profile (Plate C-1).

AREA "A", MAGNETOMETER TRAVERSE -2 (MT-2): As with MT-1, there do not appear to be any significant magnetic variations on this profile, although the noise level is somewhat higher. A three-point rolling average of individual readings would smooth the curve considerably (Plate C-1).

AREA "A", MAGNETOMETER TRAVERSE -9 (MT-9): This profile is immediately north of the Rocky Mountain grid and appears to have been designed to confirm the presence of volcanic rocks (quartz latite lava) in this area. The dipolar anomaly between 40W and 50W appears to confirm this assumption. The magnetic body apparently dips eastward at a moderate angle (Plate C-1).

AREA "A", MAGNETOMETER TRAVERSE -8 (MT-8): This profile, south and east of MT-9, also indicates the presence of the quartz latite volcanics (155W - 165W), with very similar magnetic expression. The cause of the positive anomaly between 125W and 140W is not known (Plate C-1).

AREA "B", MAGNETOMETER TRAVERSE -3 (MT-3): This traverse was designed to provide information on the northern limits of the greenstone belt. The profile clearly shows that the greenstone does not extend into this area (Plate C-2).

AREA "B", MAGNETOMETER TRAVERSE -5 (MT-5): This traverse apparently crossed the greenstone belt at or near its maximum width; approximately 6,000 feet of igneous rock are indicated. The greenstone belt is magnetically inhomogeneous, suggesting the possiblity of layering (Plate C-2).

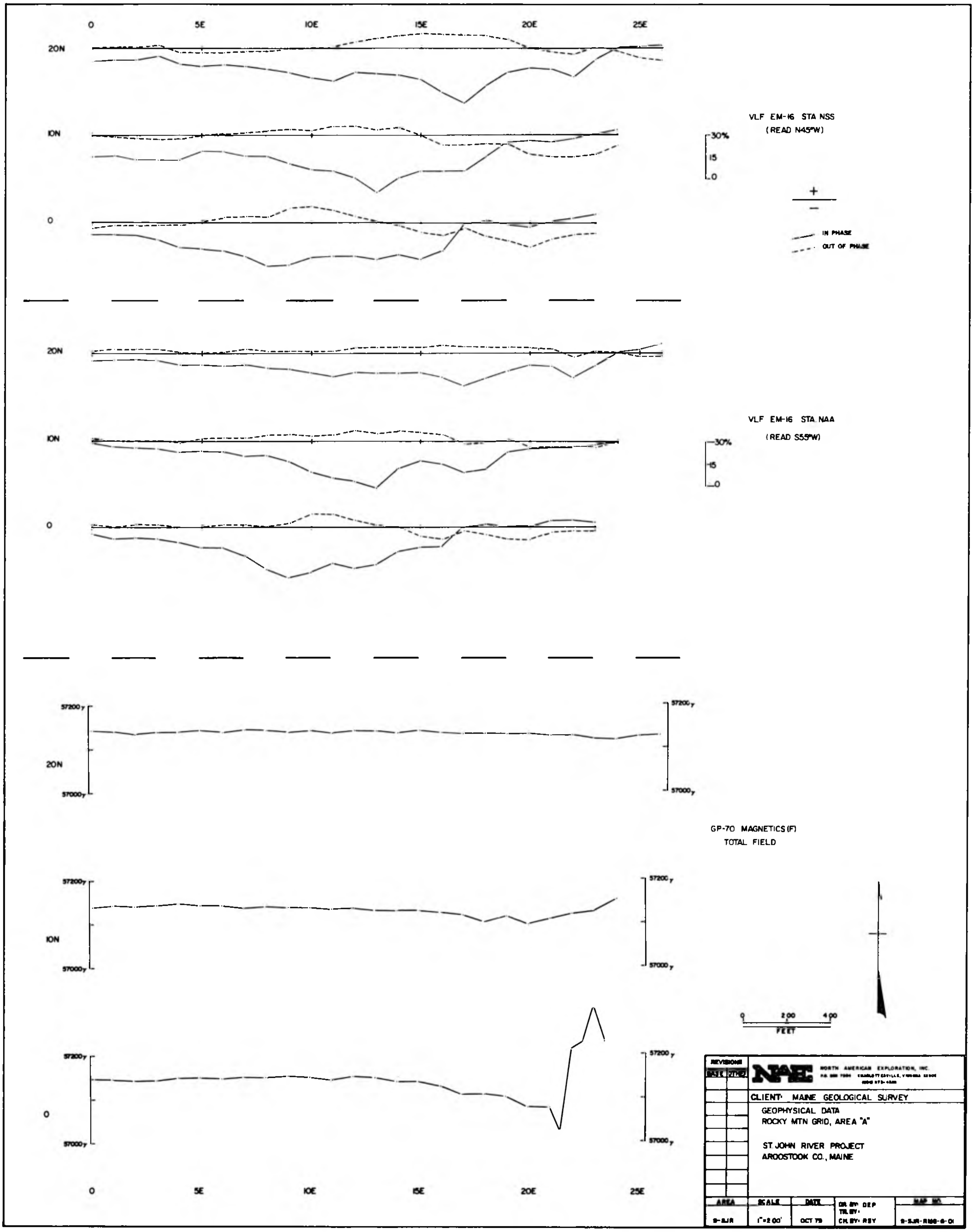
AREA "B", MAGNETOMETER TRAVERSE -4 (MT-4): Although it is too far distant from MT-5, about four miles, to demonstrate physical continuity, the MT-4 profile suggests that the greenstone belt extends to this longitude, with a width of less than 3,000 feet. The strongly dipolar magnetic signature persists (Plate C-2).

AREA "C", MAGNETOMETER TRAVERSE -6 (MT-6): This magnetic variation profile is basically featureless, indicating that the greenstone belt terminates between traverses MT-4 and MT-6 (Plate C-3).

AREA "C", MAGNETOMETER TRAVERSE -7 (MT-7): Available geologic maps do not show any igneous bodies in the area of the two magnetic anomalies on this traverse (145W and 200W). It appears, from the magnetic signatures, that the eastern anomaly is related to an andesite body and the western anomaly to a felsic volcanic bed (Plate C-3).

The magnetometer is an effective tool in delineating igneous rock masses within the overall study area, both the quartz latite lavas in the northern area and the greenstone in the central area. In such delineation, the magnetometer survey also outlines environments within which sulfide bodies might be expected to occur.

The Rocky Mountain grid was surveyed with magnetometer and VLF-EM, and the results are graphically depicted on Plate C-4. The magnetic variation profiles show that the southernmost line (Line "0") crossed into the volcanic rocks at about 22E, and the intermediate line (Line 10N) closely approached the volcanic belt. Other than these departures, the profiles are featureless. In the VLF-EM survey, both east coast stations, NAA-Cutler and NSS-Annapolis, were utilized. With the existing geographic-geologic relations, NSS provides the better electromagnetic coupling. The NSS-oriented survey mapped a weak, normal, in-phase crossover near the eastern end of each traverse line, and a better defined, reverse, out-of-phase crossover 200-400 feet to the west. The data from the NAA-oriented survey are very close, in all respects, to those of the NSS-oriented survey. In both cases, very slight, gradational changes in conductivity contrast are indicated, possibly due to an increase in carbon (graphite) or iron sulfide content toward the east end of each traverse. The data suggest that the EM anomaly is, perhaps, best classified as "stratigraphic". However, the fact that the out-of-phase crossover is verified by a valid cxHM anomaly, on all three traverses, cannot be ignored.



REVISIONS

BASE	OTHER

NORTH AMERICAN EXPLORATION, INC.

CLIENT: MAINE GEOLOGICAL SURVEY

GEOPHYSICAL DATA
ROCKY MTN GRID, AREA "A"

ST. JOHN RIVER PROJECT
AROOSTOOK CO., MAINE

AREA	SCALE	DATE		MAP NO.
9-SJR	1"=200'	OCT 79	DR. BY: DEP TR. BY: CH. BY: RSY	9-SJR-RM6-6-01

PLATE C-4

APPENDIX D

EVALUATION OF THE MINERAL POTENTIAL
UPPER ST. JOHN RIVER VALLEY
AROOSTOOK COUNTY, MAINE
1979

RECONNAISSANCE SURFICIAL GEOLOGY NORTHWEST OF THE ST. JOHN RIVER BETWEEN ALLAGASH, MAINE, AND ST. PAMPHILE, QUEBEC

by

Thomas Lowell

Institute for Quaternary Studies
University of Maine at Orono
Orono, Maine 04469

Submitted to the

Maine Geological Survey
Department of Conservation
Augusta, Maine

for work under contract to
New England Division, Corps of Engineers

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INTRODUCTION

This section describes the surficial geology of the area northwest of and parallel to the St. John River, adjacent to and within the impoundment area of the proposed Dickey-Lincoln School Lakes project (Fig. D1). Field mapping conducted during July and August, 1979, was concurrent with and supplemental to bedrock, geochemical, and geophysical studies of the same area. Ground traverse and air photograph interpretation of 67,000 hectares resulted in description and delineation of fourteen different surficial units. All units, stratigraphic relationships, and associated surficial features are described in this section.

Previous studies in this area are limited in number and scope, but are summarized below. During a state-wide gravel inventory, Leavitt and Perkins (1935) investigated several gravel deposits in the town of Allagash including irregular kames and kame terraces along the St. John and Allagash Rivers (Plate D1) which they concluded formed adjacent to ice tongues lying in the river valleys. Further, they concluded as the ice tongues melted, lakes formed as indicated in the following quote: "The Little Black River Valley above Johnson Brook Mountain was filled by a long, narrow lake which represented the melting place of the last ice tongue" (Leavitt and Perkins, 1935, p. 176). However, their gravel inventory did not extend beyond Allagash, thus, "Little is known about the glacial geology of the headwaters of the St. John and Allagash" (Leavitt and Perkins, 1935, p. 176). Hence remained the knowledge of the area's surficial geology until Boudette and others (1976) noted surficial features during bedrock reconnaissance mapping of the area in 1966. They reported a thin layer of glacial drift consisting primarily of loose sandy till containing erratics. Further, they noted that thin till deposits cover uplands,whereas thick till and gravel deposits of kames, eskers,

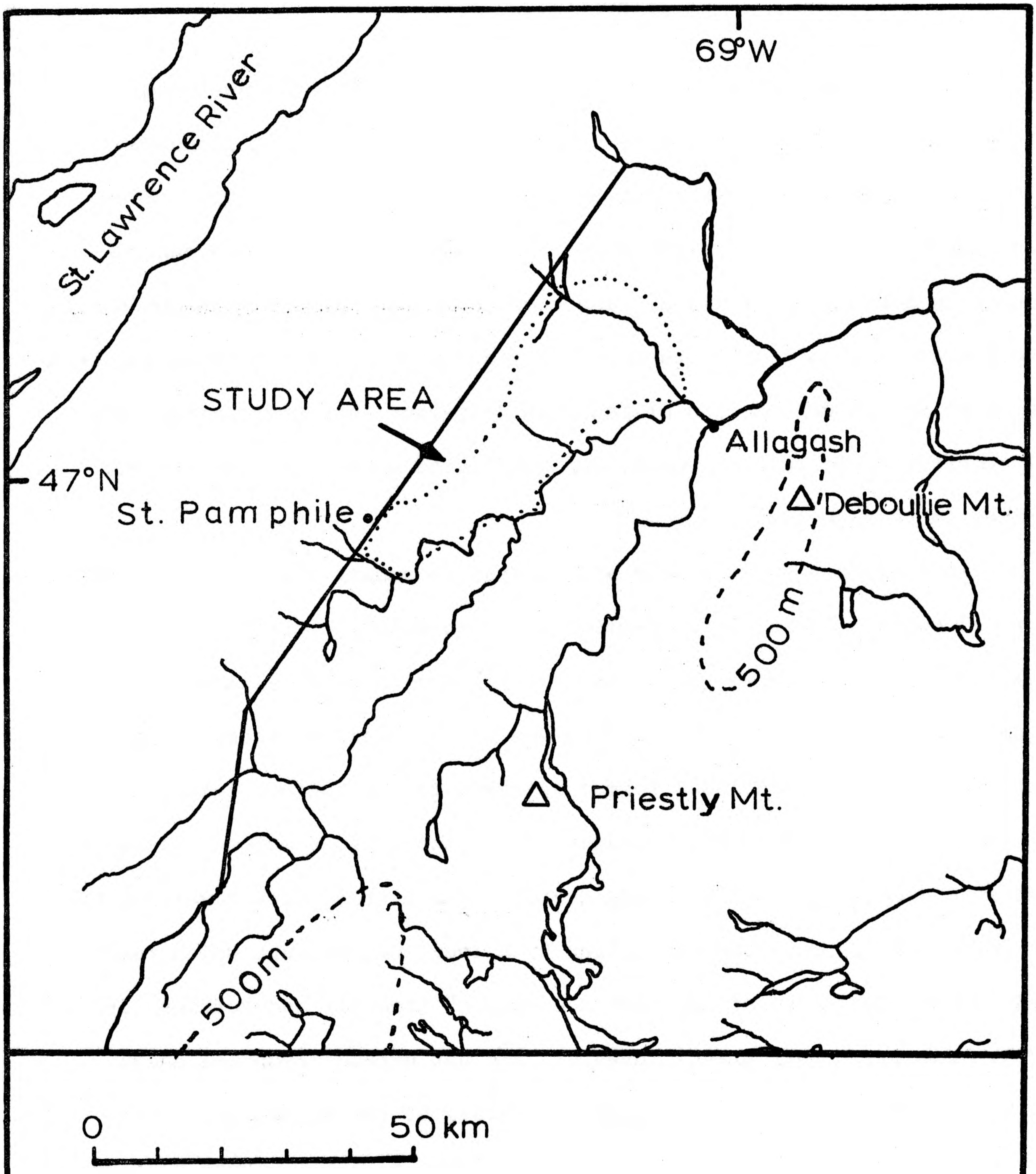

Figure D1. Location of study area in northwestern Maine. Dotted line shows the extent of systematic coverage.

and deltas lie in river valleys. McKim and Merry (1975) refined the extent of surficial deposits during a survey to determine the abundance and nature of construction materials. They identified and delineated fourteen surficial units based on air photograph interpretation. For the investigated area, they found till units cover the largest area, till over rock units the second largest area, and exposed rock units the third largest area. This suggests a thin drift cover. Gravel deposits of varying types constituting minor surficial units concentrated in the valleys and lowlands were also mapped. These three studies represent the total previous investigations concerned with the surficial geology of the area.

SURFICIAL DEPOSIT DESCRIPTIONS

The deposits are described in the order that reflects general age relationships; the first deposits described are the oldest, and the last deposits described are the youngest. However, within this relationship many local variations in age occur. As Boudette and others noted (p. 25, 1976), one meter or less of drift covers the uplands, whereas thick and often complex drift units lie in the valleys. This drift cover is comprised of six deposit types with fourteen different morphological expressions. Planimetric area determinations of each morphological expression and deposit type are listed in Table D1.

Bedrock Unit (rk)

Erosion and transportation of bedrock units, described in Appendix A, determine the character of surficial deposits. Glacial abrasion of fine-grained rock units supplied the material for the fine-grained, compact till, and clasts of soft rock, glacially quarried, were quickly rounded during glacial and fluvial transport. The low relief of bedrock and a drift mantle allow few natural exposures. Outcrops do occur along streams and in areas where logging operations have removed the drift cover, and these exposures and areas with less than 1 m drift cover are identified in Plate D1.

Till Units (Qt)

Till units cover 75 percent of the study area and show a wide range of composition, texture, and color. However, on the basis of stratigraphic position, the surface till deposits represent one episode of glaciation. Differences in the tills result from changing depositional environments and post-depositional modification. Observed till thickness ranges from less than 1 m on uplands to over 4 m in stream valleys, and as Boudette and others noted (1976, p. 25),

Table D1. Estimated Area of Surficial Deposits

Part A: Morphological Expression

Deposit	Map Symbol	Area Covered (Hectare)	%Total
Alluvial fan	Qal-f	64	<0.1
Alluvium	Qal	3,020	4.5
Gravel	Qg	748	1.1
Deltas	Qg-d	536	0.8
Eskers	Qg-e	165	0.2
Kames	Qg-k	220	0.3
Kame terraces	Qg-kt	197	0.3
Outwash	Qg-o	5,880	8.7
Lake	Ql	1,263	1.9
Moraine	Qm	43	<0.1
Hummocky topography	Qmh	1,105	1.6
Swamp	Qs	3,280	4.9
Till	Qt	50,360	74.7
Bedrock	rk	591	.9
	Total Area:	67,460	100.0

Part B: Deposit Types

Deposit	Map Symbol	Area Covered (Hectare)	%Total
Alluvium	Qal	3,084	4.6
Gravel	Qg	7,736	11.5
Lake	Ql	1,263	1.9
Swamp	Qs	3,280	4.9
Till	Qt	51,510	76.8
Bedrock	rk	591	.9
	Total Area:	67,460	100.0

the north or northwest sides of bedrock hills possess somewhat thicker till covers. Although all tills show a predominance of locally derived clasts, erratics of gneiss, granite, and other igneous rocks derived from the Canadian Shield are present throughout the study area in amounts of less than one percent. The surface till is light brown to brown (Munsell soil colors 2.5Y 5/2-2.5Y 5/4, wet) due to oxidation, and ranges in texture from loose to compact due partially to variations in matrix size from sandy to silty-clayey. Till exposed at locations J-33 and J-61 (Plate D2) is non-calcareous, whereas till exposed at location J-49 (Plate D2) is weakly calcareous. Representative exposures of brown surface till are seen at locations J-18, J-24, J-26, J-33, J-39, J-43, J-45, J-49, J-86, and J-98 (Plate D2).

At several locations, loose fragmented bedrock, usually graywacke, constitutes the till unit. Bedrock beds are contorted, folded, and sheared such that distinction between till and bedrock is difficult. Erratic clasts and occasional fine grain matrix lenses distributed in the unit matrix show the disruption and transport of the bedrock unit. Intact, transported bedrock blocks up to 2 m high x 5 m long are present in the exposed face of J-4 (Plate D2). Occurrence of these tills appears to be a function of underlying bedrock and their distribution is unknown, but exposures are present at locations J-4, J-37, J-63, J-87, J-119, J-122A, and J-124 (Plate D2).

Till in stream exposures is gray to dark gray in color (Munsell soil colors 5Y 5/2-5B 5/1, wet) because of unoxidized graywacke and slate fragments. Compact to very compact texture of the till results from the silty to clayey matrix that is also calcareous at locations J-73, J-77, and J-115. Representative exposures of the gray till are displayed at locations J-31, J-72, J-73, J-77, J-82, J-83, and J-115 (Plate D2). The gray till was not observed exposed at the surface. However, brown till units overlying gray till units are present at locations J-73, J-80, J-85 (Plate D2), and at Grand Rapids on the St. John (Plate D1) in an exposure designated Grand Rapids A (GRA, Plate D2; Andrew N. Genes, oral communication, January, 1980).

Location J-73 (Plate D2) shows 1.5 m of laminated sand and gravel overlying 1 m of brown till above and in contact with an unknown thickness of gray till. Along the top of the brown till units groundwater seeps out of the exposure and causes local slumping of the exposure. Both tills are very compact with a silty matrix and the contact between the two units changes color over a 1 cm interval. Grain size analysis of the brown till shows 17.9 percent gravel, 28.9 percent sand, and 52.3 percent silt and clay, whereas the gray till shows 12.5 percent gravel, 29.8 percent sand, and 57.7 percent silt and clay. No differences in clast lithology are noted; however, the clasts in the gray till remain intact, whereas some clasts in the brown till have weathered in place.

At the Grand Rapids section (GRA, Plate D2), a trench in the lower portion of the exposure displays alternating brown and gray till units. Although both units have a compact silty matrix, portions of brown till are granular enough to conduct ground water to the exposure face. Water flow is fast enough to be observed, and slump scarps indicate long periods of ground water flowage. Till fabrics in the gray till (GRA-GT) and the brown till (GRA-BT, Plate D2), show similar patterns. Clast lithologies are similar except that some clasts in the brown till units are weathered in place. Location J-3 (Plate D2), near Campbell Depot Camp (Plate D1), shows till under thin outwash sediment exposed in a road ditch. The till surfaces display a brown color; however, fresh exposures display a gray color. Further, brown coloration penetrates along fractures in the gray till. Pyrite in till may contribute to the rapid oxidation, but the exact mechanism is unknown. Original till deposition left a medium compact to compact gray till that has been oxidized to form the brown till widespread on the surface. Grain size analysis of selected till samples are given in Table D2 and plotted on a triangular diagram (Fig. D2).

Till morphology is primarily ground moraine, but three other expressions are noted. At several locations till comprises small 3 m high, 10-15 m wide, less than 100 m long, ridges. These are minor moraines or ice disintegration features and are numerous along the east side of Rocky Brook (Plate D1). Further, several small moraine segments lie along the edge of the glacial trough containing the Little Black River (Plate D1). Discontinuous segments of larger moraines, Qm, delineated from air photographs lie in a belt that trends southwest from Twomile Brook to the Big Black River south of St. Pamphile (Plate D1). Small hills and irregular topography resulting from a mixture of till and gravel lie in the same belt, and this deposit is designated hummocky moraine, Qmh, on Plate D1.

Gravel Units (Qg)

Gravel units are concentrated in the valleys and display a variety of morphologic forms. For units within distinct morphology, gravel deposits are designated Qg; where gravel units have distinct morphology, a second letter on Plate D1 indicates the land form.

Large eskers (Qg-e) lie parallel to streams along the valley floors. A large esker, along the upper portion of the Little Black River (Plate D1), location J-34B (Plate D2), displays gravel imbrication indicating deposition by northward flowing subglacial water. Likewise, a smaller esker system near Johnson Brook Mountain (Plate D1) with three associated, oriented outwash fans, formed as water flowed north. Fivemile and Twomile Brooks

Table D2: Grain Size of Selected Till Samples

Sample Location	Gravel % (4-2 mm)	Sand % (2-.0625 mm)	Silt & Clay % (< .0025 mm)
J-33	33.8	29.2	37.0
J-49	32.3	21.1	46.6
J-61	30.4	29.7	39.3
J-73-I	17.9	29.8	52.3
J-73-II	12.5	29.8	57.7
J-77-I	31.6	22.1	46.3
J-77-II	46.8	35.8	17.4
J-77-III	22.2	25.1	52.7
J-115-I	19.9	35.4	44.7
J-115-II	26.4	31.0	42.6

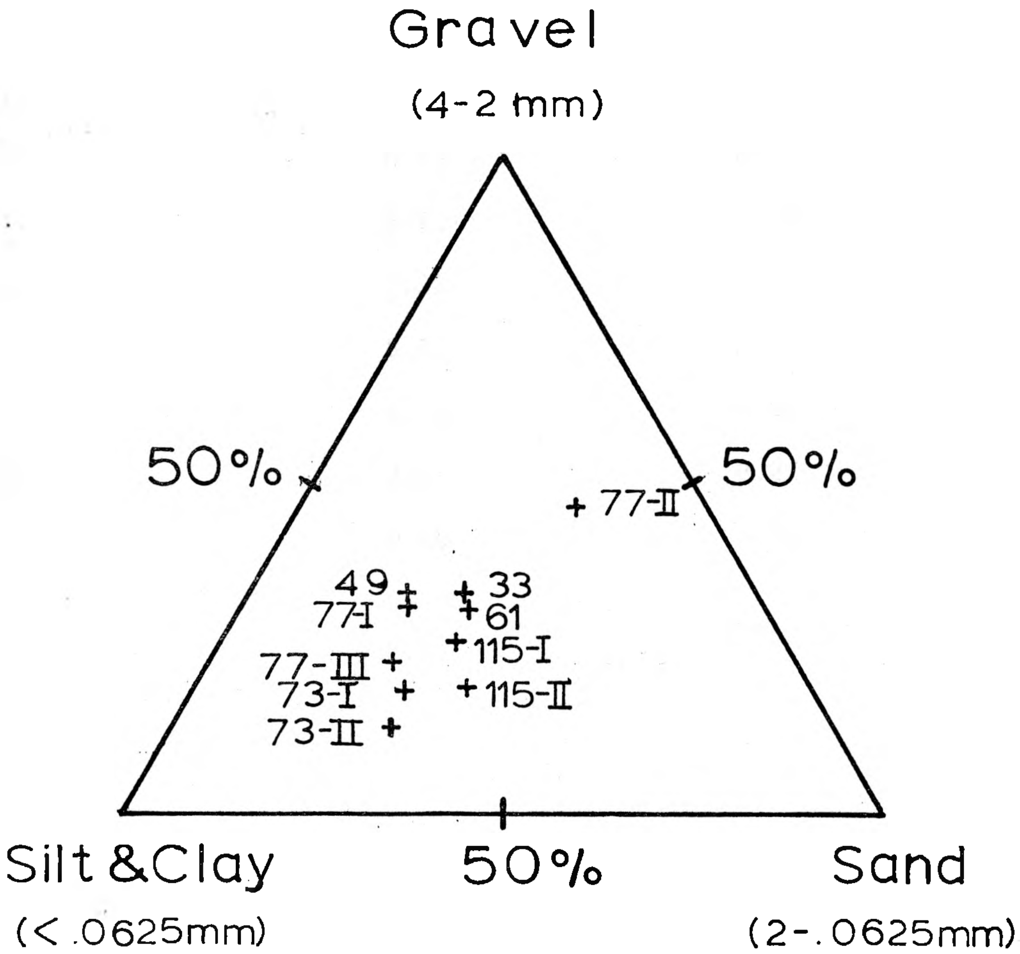

Figure D2. Grain size of selected till samples on a triangular plot.

(Plate D1) also contain small esker segments along their valley floors. These eskers formed parallel to ice flow directions in subglacial tunnels.

A second group of subglacially engorged eskers (Sudgen and John, 1975, p. 331), Qg-e, forms small gravel deposits along the south valley side of the Little Black River (Plate D1). These small, less than 200 m long and 10 m high eskers formed as meltwater, flowing along the margins of remnant glacier tongues, drained into crevasses and deposited sand and gravel perpendicular to ice flow. Logging operations are utilizing these eskers for road material (locations J-8, J-16, J-52, Plate D2).

Kames, Qg-k, represent irregular gravel deposits formed in contact with the melting glacier ice. Kames generally lie along valley sides, as several examples along the Little Black River (Plate D1) show; however, an extensive kame system lies on a hill north of Ninemile Deadwater on the Big Black River (Plate D1). Several kames in the Little Black Valley have flat tops that project from the sloping valley walls and are designated kame terraces, Qg-kt. Except along the Campbell Branch of the Little Black River (Plate D1), kames are not utilized as sand and gravel sources, although they would provide good road fill.

Outwash, Qg-o, is a flat gravel deposit resulting from glacial meltwater. Outwash deposits are typically thin, less than 3 m, and are difficult to utilize as a gravel source. Outwash deposits reported here are less extensive than McKim and Merry reported (Part II, 1975). Because separation of till deposits and outwash deposits in depressions is difficult through air photograph interpretation, many units, first interpreted as outwash, are actually till when field checked. Thus, the extent of outwash deposits was overestimated in McKim and Merry's report and may also be overestimated for areas of this report.

Lacustrine deltas, Qg-d, the last major unit mapped as gravel, were built into relic high-level lakes. Deltas range in size from less than 100 m to more than 1 km across and from 3 m to more than 8 m in thickness. A large delta near Whitney Brook (Plate D1; Location J-30, Plate D2) and a smaller delta southwest of Fivemile Brook (Plate D1; Location J-97, Plate D2) are being utilized extensively for sand and gravel. Measurements of the largest clasts in three gravel deposits are presented in Table D3. These measurements indicate the relatively high energy environments associated with glacial meltwater deposition.

Lake Sediment Units (Q1)

Lake sediment deposits, bedded clays and silts,constitute the surficial unit in two areas. A small lake sediment deposit lies in the Little Black River Valley, 4 to 5.5 km upstream of the confluence with the St. John River (Plate D1). The lake sediments, well displayed in a stream exposure known locally as the Blue Cliffs (location J-110, Plate D2), extend 9 m above the Little Black River. The blue-gray to gray sediment consists of silt and clay rhythmites. In the rhythmites exposed at location J-110 (Plate D2), silt layers range from less than 1 mm to 12 mm thick. This exposure displays 2 m of fine to medium sand overlying 4 m of rhythmites that number a minimum of 500 couplets. The lowest 2 m of exposure consist of 1 mm thick clay laminations. Although calcareous concretions are present in portions of this exposure, dropstones are rare.

A large lake sediment deposit covers the valley bottoms of the Big Black River and the Shields Branch (Plate D1). Lake sediments fill the valley, thus the valley has a flat floor. Although little evidence is available to determine the thickness of these lake sediments, stream erosion has exposed a minimum of 5 m of lake sediment.

Table D3: Clast Size in Selected Gravel Deposits

Location	Number of Measurements		Longest Axis (cm)	Intermediate Axis (cm)	Shortest Axis (cm)	Deposit
J-2	25	$\bar{x}$	12.4	8.2	5.5	Outwash
		s	2.8	1.5	1.5	
J-7	10	$\bar{x}$	10.5	6.7	3.7	Outwash
		s	1.9	2.1	1.1	
J-16	25	$\bar{x}$	9.8	7.0	3.6	Esker (valley)
		s	2.3	1.9	1.1	

Alluvium Units (Qal)

For this report, alluvium is considered to be silt, sand, and gravel that is deposited in fluvial drainage systems, whereas outwash is considered to be sand and gravel deposits that were deposited by glacial meltwater drainage systems. The McKim and Merry report (Part II, 1975) mapped gravel deposits along the St. John River (Plate D1) as outwash, O; outwash terraces, Ot; and alluvium terraces, At; however, field associations between gravels, silts, and sands indicate deposition in postglacial and periglacial river systems. Therefore, this report considers these to be alluvial deposits. Major alluvium deposits occurring along the St. John River (Plate D1) consist of bedded sands and gravels over till as the stratigraphy of location J-72 (Plate D2) exemplifies. Eight meters of alluvium displaying sedimentary structures indicate paleo-riverflow parallel to the present river. Below the alluvium deposit lies a compact silty gray till being eroded by the present St. John River. Alluvium deposits on smaller streams consist of sands and silts deposited as streams meander. The Little Black River (Plate D1) and other smaller streams show these deposits.

A minor group of gravel deposits, designated alluvial fans (Qal-f), occur where high-gradient tributary streams deposit boulders upon entering a larger, less competent stream. The cone shaped deposits lie on valley walls and indicate river level at the time of deposition. An alluvial fan above the present St. John River at Seminary Brook (Plate D1) indicates a former high level of the river, possibly the same river level that deposited the alluvial gravels at location J-72 (Plate D2). The alluvial fan at the mouth of Johnson Brook (Plate D1) extends above the present river level and records the progressive lowering of the Little Black River (Plate D1).

Swamp Unit (Qs)

Comprising 5 percent of the surface area, swamps result as glacial drift blocks small drainage systems which allows organic accumulation. These deposits are thin, wet, and difficult to investigate; vegetation changes on air photographs are the best way to delineate this deposit. Peat bogs also comprise deposits mapped as swamp. Peat bogs are slowly encroaching upon lakes such as Fox and Bruleau Ponds (Plate D1) and several bogs appear to be former lakes.

OTHER SURFICIAL FEATURES

Glacial Striations

Striations generally reflect former glacial ice movement; however, not all striations in the study area are glacially produced. Along larger streams and rivers, striations reflect winter and spring river-ice flows. Striations parallel to the St. John River near Seminary Brook (Plate D1) cut across a USGS Bench Mark tablet (R57). Therefore, stream exposures of bedrock are usually not used for striation measurements. All striations plotted on Plate D1 result from glacier ice and indicate former ice movement.

This report distinguishes between striation trend and striation direction. Trend refers to the orientation of a striation measured with respect to north and may indicate ice movement in either of two directions 180° apart. Direction refers to the measured orientation of a striation where one unique ice movement bearing can be determined. Striations are present on less than 30 percent of the more than 300 bedrock exposures examined and stoss-and-lee morphology allowed direction determination at 63 percent of the striation locations.

The oldest striations in the study area indicate ice movement directly due east. Numerous exposures possess west-east trending striations, but only rarely can the eastward movement be determined. Evidence from a few locations, S9 and S17, and from till fabric data, indicate the ice movement to the east and not to the west. Examples of east-west trending striations are present at locations S9, S13, S17, S18, S23, S24, S40, S47, S69, S72, and S82 (Plate D2).

Superimposed on the eastward striations are northward directed striations. Well developed stoss-and-lee forms on resistant bedrock outcrops near the Little Black River (Plate D1) allow determination of the northward direc-

tion. Striations do not record the change from east moving ice to north moving ice; no observed striations trend between east and north. Although north-south trending striations are common, development of stoss-and-lee forms has not occurred near the Big Black River (Plate D1) and direction determination in this area is difficult. Locations S3, S6, S7, S11, S16, S17, S19, S20, S27, S28, S31, S34, S35, S37, and S40 (Plate D2) show northward pointing striations, whereas locations S1, S2, S10, S13, S18, S26, S33, S33B, and S38 (Plate D2) show north-south trending striations. Locations S3, S17, and S40 (Plate D2) show the northward trending striations superimposed on eastward trending striations.

The youngest striations indicate a gradual shift of ice movement from north to northwest. Locations S5, S13, S15, S16, S18, S22, S23, S25, S42, S50, S65, S67, S68, S73, and S79 (Plate D2) all indicate ice movement to the northwest, whereas locations S2, S27, S28, S29, S32, S32A, S44, S45, S46, S47, S49, S66, S69, S70, S71, S73, S74, S75, S76, S78, S81, and S82 (Plate D2) all indicate a northwest-southeast trend and the shift from north to northwest is seen at locations S16 and S81. No observed locations give evidence of ice movement to the southeast.

Till Fabrics

A second means for identifying former glacier movements, till fabrics, involves analyzing rock clast orientations in till deposits. The longest axis of the clasts are aligned parallel to ice flow and dip toward the direction of movement (Harris, 1969). To determine the clast alignment, 25 elongated stones with longest axis more than twice the next longest axis were measured for orientation and dip in till exposures more than 1 m deep. The 25 measurements constitute a data set analyzed two ways. First, each data set is plotted as a Rose diagram from which visual inspection determines the trend of glacier movement. Second, each data set is statistically reduced to a vector with an eigenvalue computer program (Mark, 1971). This analysis determines the preferential dip direction and indicates the statistical validity of each data set. Smaller values for S_3 indicate more "significantly" preferred orientations. If the S_3 values for a data set exceed the 5 percent values given in Table D3, the data set cannot be separated from a random data set at the 95 percent confidence level. Till fabric data is plotted beside the appropriate stratigraphic section on Plate D2. The circles on the diagrams represent 5 stones falling within one 10° class. The triangle on the diagram represents the position of the eigenvalue longest axis plotted on the lower hemisphere of Schmit Stereonet. An "x" beside a till fabric diagram indicates the eigenvalue is not significant at the 95 percent confidence level.

Of the ten data sets collected, six show significantly preferred orientations, whereas the other four show statistically random orientations. Two factors may account for the randomly oriented data sets. First, the clasts were deposited in an ablation till rather than a basal till (Drake, 1971). Second, post depositional modification such as frost action disrupted clast orientation. Such disruption may account for the random patterns at locations J-26 and J-77-U (Plate D2), although the possibility that they were deposited in a random pattern cannot be excluded. Although the form is similar, the fabric pattern from the gray till (GRA-GT, Plate D2) at Golden Rapids, is random, whereas the fabric pattern from the brown till (GRA-BT, Plate D2) is not. Why the two, collected at depth from the same deposit 2.5 m apart are different is not clear, but may indicate variations within one till unit as Harris (1969) has observed.

Table D4: Till Fabric Eigenvalue Data

Location	No. Stones N	Longest Axis			Intermediate Axis			Shortest Axis		
		ORT	DIP	S_1	ORT	DIP	S_2	ORT	DIP	S_3
J-4	25	153	23	.444	257	32	.393	32	49	.162
J-26	25	195	3	.462	105	4	.343	316	85	.193*
J-31	25	153	11	.486	249	30	.362	45	57	.151
J-33	25	271	16	.563	1	1	.326	96	74	.110
J-61	25	335	16	.507	238	20	.290	101	64	.202*
J-77-U	25	168	13	.427	276	52	.369	67	35	.203*
J-77-L	25	272	21	.615	154	50	.278	15	32	.106
J-115	25	125	27	.651	224	19	.230	347	56	.117
GRA-BT	25	261	7	.510	147	73	.297	354	15	.132
GRA-GT	25	266	21	.598	140	57	.223	6	24	.178*

Significant values if S_3 is less than:

N	10%	5%	1%
20	.167	.152	.124
25	.183	.169	.144
30	.196	.184	.160

(Modified from Mark 1971)

*Data set does not possess "significant" orientation at the 95 percent confidence level.

The data sets showing preferred orientation indicate the same ice movement directions as the striation data; however, insufficient evidence is available to assign relative age relationships to these directions. Location J-33 (Plate D2), north of an esker and its associated gravels (Plate D2), possesses a due east fabric. The till, medium-compact, oxidized, and sandy textured, covers the west side of a small hill and forms two small, 2-3 m high ridges 100 m apart that trend northeast-southwest. A road exposure in the south ridge was the sample location. This location is an anomaly because no other surface till exposure possesses an east-trending fabric. Location J-77-L (Plate D2) is a compact silty gray till exposed on Fivemile Brook (Plate D1). The due east fabric is developed to the extent that boulders in the stream exposure trend east-west. An east-trending fabric is also present in brown till at the Golden Rapids Section (GRA-BT, Plate D2).

Data sets from locations J-4 and J-31 point northwest whereas location J-115 points west-northwest (Plate D2). Location J-4 (Plate D2) a borrow pit southwest of Rocky Mountain just north of the "Rabbit Turn" (Plate D1), displays a loose, oxidized surface overlying glacially contorted graywacke beds. Location J-31 (Plate D2) is a very compact silty gray till under fluvial sands and gravels on the Little Black River near Whitney Brook (Plate D1). Fabric data and stratigraphic relationships at location J-31 (Plate D2) indicate late glacial flow northwest up the Little Black River valley. This is similar to location J-115 (Plate D2), where a compact clayey red till lies between two lake deposit units. The red till possesses a fabric indicating glacial flow northwest up the Shields Branch valley (Plate D2).

Glacial Moraines

Moraines, briefly discussed under till units, are further described below because of their importance in reconstructing glacial history. Two moraine systems, representing different phases of deglaciation, occur in the study area. The larger system lies northeast-southwest across Fivemile and Twomile Brooks (Plate D1) and is comprised of different elements along its length. Several ridges from 2 m high and 20 m wide to 15 m high and 150 m wide lie between areas of hummocky topography, which consists of an undulating surface 5-10 m high made up of interbedded till and gravel deposits. During deposition of this moraine system, glacial ice lay to the southeast, occupying the St. John River valley.

The second moraine system occurs on the hills flanking the Little Black River valley (Plate D1). Several small, less than 10 m high and 100 m long, moraine segments rest along the upper valley limit and longer moraine segments drape around bedrock hills near Knowland Brook (Plate D1). Different elevations of moraine segments and kame deposits indicate progressive lowering of active ice in the Little Black River valley (Plate D1). Although no detailed stratigraphy is available, kames, kame terraces, eskers, deltas, lake deposits, and minor moraines near Rocky Brook (Plate D1) suggest an interfingering relationship between southeast ice retreat and lake formation in the valley.

Glacial Meltwater Channels

Relic fluvial channels mark the positions of former drainage paths through the study area, and air photograph interpretation of the relic fluvial channels allows placement into one of two general groups. The first channel group cuts deeply into bedrock and forms long, narrow channels extending from the valley top to the valley floor. Active underfit streams often follow these channels down to the valley floor, as seen at Knowland Brook on the Little Black River (Plate D2). Other examples of the first channel group occur along the Little Black River and Fivemile Brook (Plate D2). The second channel group is short, wide, and cut into small hills and ridges. A complex system of these channels lies near Seminary Brook along the St. John River (Plate D1). Other examples of the second channel group occur in the southern portion of the study area and often occur in association with outwash sediments.

Glacial Erosion

Glacial erosion had minor impact on the topography of the region. The remnant topography of mature drainage with its lack of lakes suggests little glacial scouring of the bedrock surface. The region might be classified a landscape of little or no sign of erosion (Sudgen and John, 1976, p. 193), but complete removal of regolith indicates some glacial erosion. Further, absence of stoss-and-lee forms on bedrock hills indicates minor glacial erosion. One major glacial erosion feature, a trough, extends from Boat Landing Mountain to Allagash (Plate D1) and contains the Little Black River. The glacial trough developed, in part, prior to the last glaciation, as thick complex drift deposits and separated till layers, present in the lower portion of the valley, indicate.

Fossil Ice Wedge Casts

Four fossil ice wedge casts present in various deposits near the Little Black River (Plate D1) indicate cold post-glacial climatic conditions. The only cast in till penetrates into the disrupted graywacke at location J-4 (Plate D2). Although borrow activity removed the top portions of the section, the cast is at least 35 cm wide at the top and narrows to a point along its 140 cm length. Coarse gravel penetrating at least 80 cm of sand and inclined at a 60° angle to the horizontal, outlines the fossil ice wedge cast at location J-30 (Plate D2). Due to the coarse gravels above and below the sand, extent of the cast could not be determined. At location J-99 (Plate D2), on a kame terrace along the Little Black River (Plate D1), two fossil ice wedge casts appear about 10 m apart. The better developed, larger clast is a minimum of 140 cm deep and 44 cm wide at the top. A cobble gravel lens, vertically imbricated, maintains a nearly constant width down the cast. The presence of the fossil ice wedge casts in the glacial deposits indicates cold climatic conditions after glacial recession.

CONCLUSIONS

The thin drift deposits across the study area represent the most recent geological activity, and although not necessarily the most important, drift deposits represent the most obvious geological features. From an understanding of drift deposition manner and chronology, methods can be devised to obtain geological information concealed by the drift. Therefore, a relative sequence of events or phases, deduced from the field evidence, follows. However, no attempt is made to place this sequence into a regional glacial chronology.

The first phase consists of a strong glacial movement from the west to the east overrunning the study area. This glacial phase deposited a compact silty-clayey gray till of predominantly local clast lithologies, with about 1 percent erratic clasts derived from the Canadian Shield. Most surficial deposits present before this phase, were removed and only those deposits lying in the larger river valleys, detectable only in drill holes remained. This first phase removed previous materials and replaced it with compact till.

Ice motion, first to the east, slowed, stopped, and became directed to the north, thus marking the beginning of the second phase. The compact gray till covering uplands became incorporated into the northward flowing ice and limited bedrock erosion produced striations and small stoss-and-lee forms. However, some topographic lows retained the early till and these stratigraphic sections indicate continuous ice cover during ice motion change. Although change from the first phase to the second phase was abrupt, change to the third phase was gradual; north moving ice shifted direction to northwest and lost strength.

The fourth glacial phase begins as the ice margin retreated southeast from Canada into the study area; deposition of proglacial and ice marginal units accompanied the retreat. Regional drainage paths during this phase are problematic but locally lakes developed in blocked valleys and depressions. Exact ice positions during the fourth phase are unknown due to the complexity, abundance, and distribution of proglacial fluvial deposits; however, evidence for at least one glacial standstill and one readvance is available. A glacial standstill produced the hummocky topography that trends northeast across Fivemile and Twomile Brooks (Plate D1). Overrun lake sediments at locations J-85 and J-115 (Plate D2) indicate a local northwest ice readvance that deposited 2-3 m of till. Further, location J-115 (Plate D2) shows deposition of sediments in a proglacial lake after the readvance. Moraine segments in the southern portion of the study area mark the ice margin position; whether these positions are a glacial standstill, readvance, or both is not known. As the regional ice margin retreated southeast through the study area, outwash deposits, meltwater channels, kame deposits, and lake deposits formed due to production of glacial meltwater.

Contemporaneously, or somewhat later than the above events and placed in the fourth phase, an ice tongue in the Little Black River valley (Plate D1) produced similar deposits. Subglacially engorged eskers, kames, and kame terrace deposits formed as meltwater flowed along the margin of the ice tongue, while two subglacial esker systems formed at the ice base. Moraines along the valley walls mark progressive lowering of the ice tongue as lake and delta deposits formed in a succession of ice dammed lakes. Cold climates prevailed in the study area at this time causing formation of ice wedge casts in till and gravel deposits.

After final glacial retreat, marking the fifth phase, fluvial processes dominated the surficial activity. Drainage patterns, somewhat disrupted by glacial deposition, became reestablished in the St. John River, Big Black River, and Little Black River (Plate D2). Smaller fluvial systems, with less erosive power, became reestablished slowly with some streams allowing swamp deposit production. Alluvial development along the rivers depends on local base levels; where controlled by base levels, the streams cannot downcut and thus must meander, producing alluvial deposits. Where not controlled by base levels the streams erode the glacial till and gravel deposits. These processes are active today. A second process active today is soil development which occurs on all exposed deposits at rates depending on deposit type, deposit composition, climate, exposure, and vegetation cover. Schematic representations of the above phases are shown on Plate D1.

The above discussion indicates caution should be exercised when interpreting surficial deposits to determine source areas for mineral anomolies. Complex actions of glacial deposition, erosion, redeposition, and fluvial erosion, transportation, and deposition, hide source areas. Fluvial deposits are particularly confusing as they often show distantly derived clasts and have complex histories. Basal till deposits are better for determining source area. These deposits may represent simple erosion, transportation and deposition; if so, local striation and stratigraphic studies can identify a probable source area. The chance of success using till can be increased through studies of the lowest portions of the deposit, as local materials are concentrated there. Such methods have been employed successfully in Canada (for example, Shilts, 1975, 1976; Alley and Shatt, 1976). In addition, glacial deposits affect groundwater movement; gravel deposits provide an easy path for water movement, whereas compact clayey tills are almost impervious. Therefore, distribution and stratigraphy of surficial materials will influence rates and paths of groundwater movement.

ACKNOWLEDGEMENTS

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MINERAL RESOURCE POTENTIAL

UPPER ST. JOHN RIVER VALLEY

STRATIFIED ROCKS

Age	Map unit	Description
Early Devonian	Dss Dsh Dsg	**SEBOOMOOK FORMATION** Dss: Gray slate with lesser graywacke Dsg: Graywacke with equal or lesser slate Dsh: Hafey Mountain Member: siliceous quartz arenite
Late Silurian	Sf Sfg	**FIVEMILE BROOK FORMATION** Sf: Calcareous slate; cleaved argillaceous limestone; biomicritic limestone Sfg: Greenstone Member: andesitic sills, flows and pyroclastic rocks
Silurian	Sr	**ROCKY MOUNTAIN QUARTZ LATITE** Quartz latite; locally with eutaxitic texture
Middle Ordovician-Early Silurian	OSdm OSdma OSdm	**DEPOT MOUNTAIN FORMATION** OSdm: Gray slate and gray lithic graywacke OSdma: Aquagene Tuff Members: felsic water-laid tuff; lithic tuff; resedimented lithic tuff; volcanogenic conglomerate
Cambrian-Early Ordovician(?)	Coe	**"ESTCOURT ROAD SEQUENCE"** Gray slate and quartzo-feldspathic fine-grained sandstone; thick-bedded siliceous quartz arenite, red and green slate; tectonic disruption and fragmentation of sandstone beds common

SYMBOLS

OUTCROP DATA OBTAINED IN THIS STUDY

- Bedding attitude: inclined and vertical beds; dot indicates tops direction where known
- Cleavage attitude: inclined and vertical
- Outcrop: no structural data possible
- Plunge of small anticline
- Plunge of small syncline
- 2767 Locality referred to in text

OUTCROP DATA OBTAINED FROM BOUDETTE AND OTHERS, 1967

- Cleavage attitude: inclined and vertical
- Cleavage and bedding parallel: inclined and vertical
- Outcrop for which no structural data is available
- F117 Fossil locality

- Anticlinal axis
- Synclinal axis
- Contact
- Fault; "U" indicates upthrown block
- Limits of areas A, B, and C
- Limit of detailed coverage, this study
- A—A' Line of vertical section
- MT 7 Line of Magnetic Traverse Number 7; stippled rectangle shows zone of magnetic anomaly
- Zone of anomalously high base metal concentration

GEOLOGY BY DAVID C. ROY (BOSTON COLLEGE) ASSISTED BY MR. KEVIN MAHER. BASED ON FIELD WORK DURING JULY AND AUGUST 1979. MAP MODIFIED FROM THAT GIVEN BY BOUDETTE AND OTHERS (1976; USGS BULL. 1406). MAGNETIC PROFILES BY NORTH AMERICAN EXPLORATION, INC.

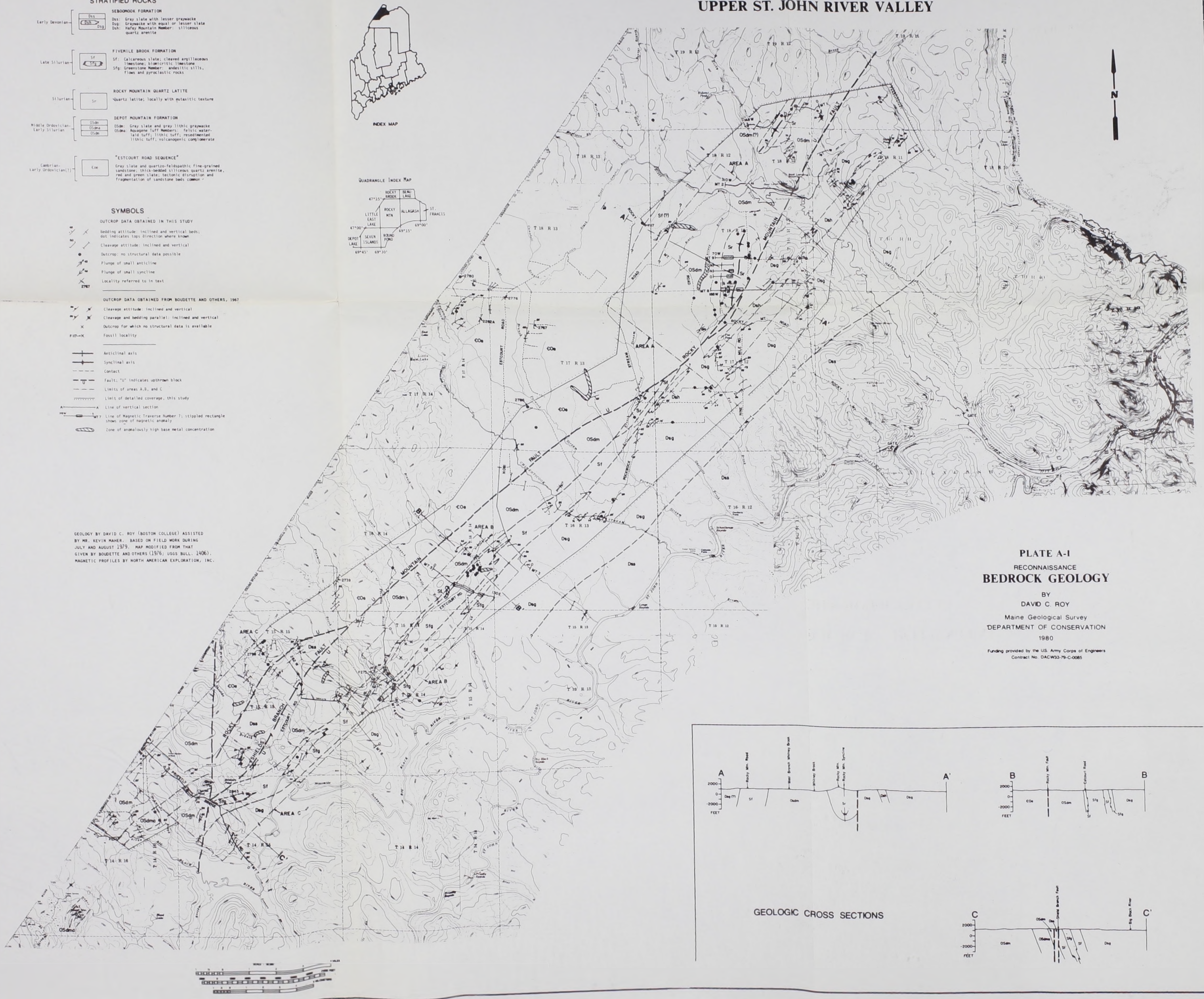


PLATE A-1

RECONNAISSANCE

BEDROCK GEOLOGY

BY

DAVID C. ROY

Maine Geological Survey
DEPARTMENT OF CONSERVATION
1980

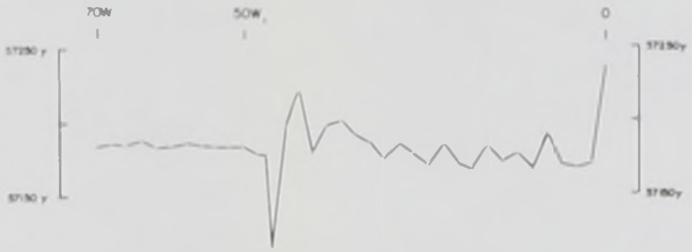
Funding provided by the U.S. Army Corps of Engineers
Contract No. DACW33-79-C-0085


PLATE B-2.
NAE
NORTH AMERICAN EXPLORATION, INC.
CLIENT: MAINE BUREAU OF GEOLOGY
GEOCHEMICAL SAMPLE LOCATION MAP
WITH GENERALIZED CxHM VALUES
SOUTH SECTION
ST. JOHN RIVER BASIN, AROOSTOOK CO., MAINE
● ≥20–≥120 ppm CxHM
◐ ≥16–19 ppm CxHM
○ ≥0–15 ppm CxHM
SCALE 1"=1/2 MILE
DATE OCT.79
DR. BY:
TR. BY: DEP
CH. BY: RSY
AREA 9-SJR
MAP NO. 9-SJR-G3-001
REVISIONS
BASE
OTHER
MILES
0
LIMITS OF AREA "B"
LIMITS OF AREA "C"
T 17 R 14
T 16 R 13
T 16 R 14
T 15 R 13
T 15 R 14
T 15 R 15
T 14 R 14
T 14 R 15
CHIMENTICOOK STREAM
Little Rock Lake
North Branch
Twomile Brook
South Branch
Branch of Fivemile Brook
Fivemile Brook
ST JOHN RIVER
BIG BLACK RIVER
Deadwater
Ninemile
Shields Branch
St Amand Brook
Charles Pond
Bradley Pond
PRIVATE
QUEBEC
MAINE
CANADA
UNITED STATES
L'ISLET CO
AROOSTOOK CO
KA CO
U S Customs
Powers Boundary


PLATE B-1
NORTH AMERICAN EXPLORATION, INC.
REVISIONS
BASE
OTHER
CLIENT: MAINE BUREAU OF GEOLOGY
GEOCHEMICAL SAMPLE LOCATION MAP
WITH GENERALIZED CxHM VALUES
NORTH SECTION
ST. JOHN RIVER BASIN, AROOSTOOK CO., MAINE
● ≥20-120 ppm CxHM
◐ ≥16-19 ppm CxHM
○ ≥0-15 ppm CxHM
AREA
9-SJR
SCALE
1"=1/2 MILE
DATE
OCT 79
DR. BY:
TR. BY: DEP
CH. BY: RSY
MAP NO.
9-SJR-GN-001
MILES
LIMIT OF AREA "A"
T 17 R 13
T 18 R 13
T 18 R 12
T 17 R 12
T 19 R 12
T 19 R 11
T 18 R 11
T 17 R 14
Pocwock Stream
Pocwock Branch
West Branch
Campbell Branch
Little Black River
Black River
Whitney Brook
Rocky Mtn
Fox Pond
Rocky Brook
Dead Brook
Hafey Mountain
Little Hafey Brook
Yankeetuladi Brook
Yankeetuladi Pond
Mud Pond
Togue Pond
Rideout Pond
Priestly Mountain
BEAU LAKE
MAINE
QUEBEC
NEW BRUNSWICK
PRIVATE
750
1000
1250
1500

MT-1

MT-2



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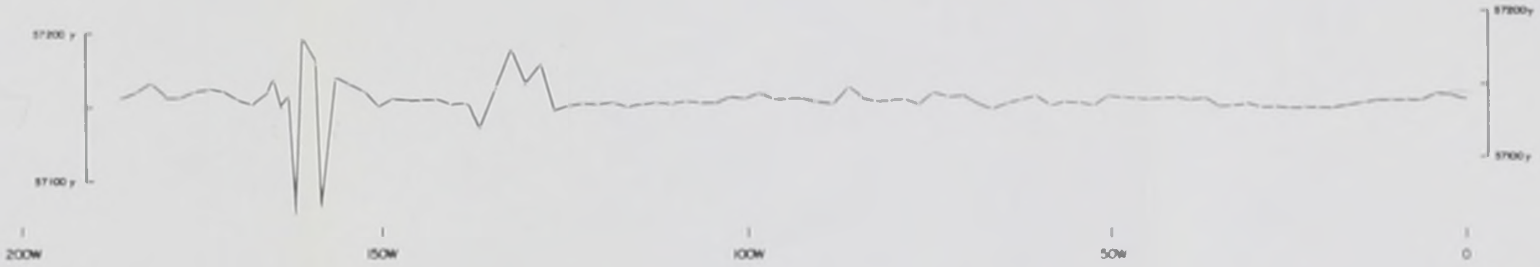

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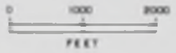


NOTE:

SEE INDEX MAP FOR LINE
LOCATION AND ORIENTATION

REVISIONS

NAE NORTH AMERICAN EXPLORATION, INC.

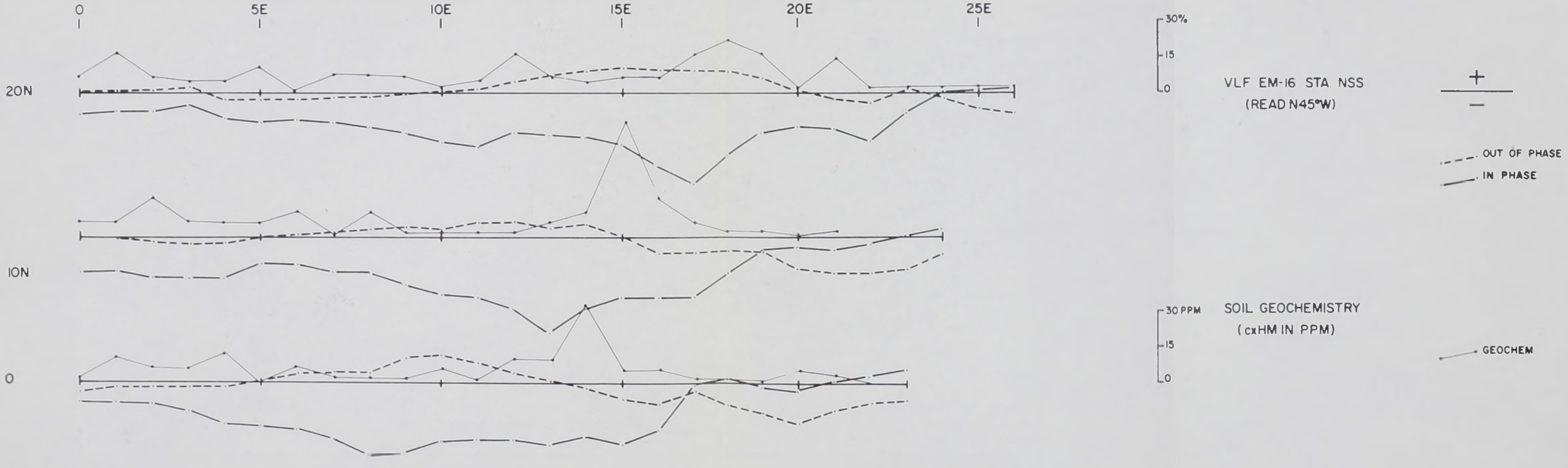
CLIENT: MAINE GEOLOGICAL SURVEY

MAGNETIC VARIATIONS
RECON LINES, AREA "A"

ST. JOHN RIVER PROJECT
AROOSTOOK CO., MAINE

AREA	SCALE	DATE	DR BY: DEP TR BY: CH BY: RBY	MAP NO.
9-SJR	1"=1000'	OCT 79		9-SJR-AMT-001

PLATE C-1



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BASE	OTHER

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(804) 973-4328

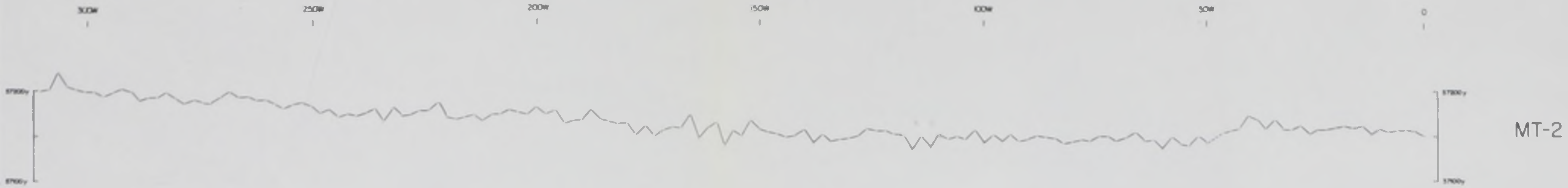
CLIENT: MAINE GEOLOGICAL SURVEY

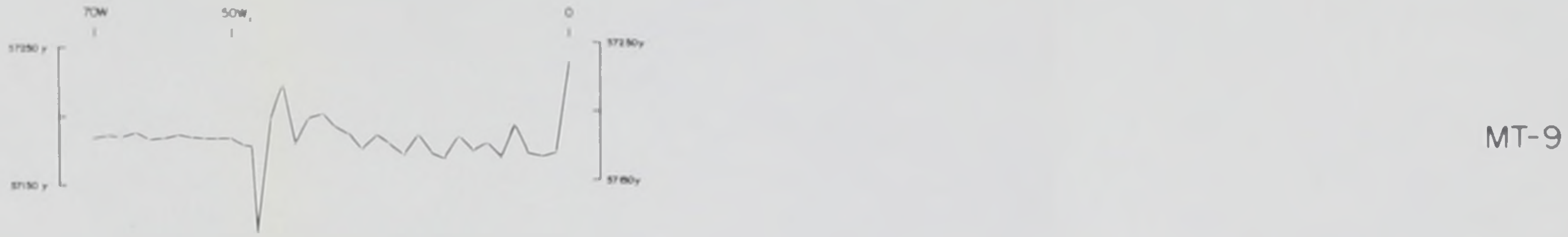
GEOPHYSICAL - GEOCHEMICAL COMPARISON
STATION NSS ONLY
ROCKY MTN GRID, AREA "A"

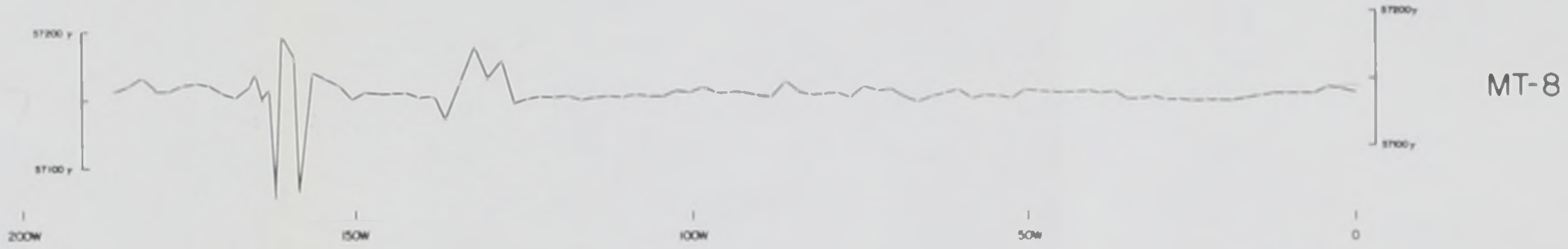
ST. JOHN RIVER PROJECT
AROOSTOOK CO., MAINE

AREA	SCALE	DATE		MAP NO.
9-SJR	1" = 200'	OCT. 79	DR. BY: DEP TR. BY: DEP CH. BY: RSY	9-SJR-RMG-GC-001

PLATE B-3







0 1000 2000
FEET

NOTE:

SEE INDEX MAP FOR LINE
LOCATION AND ORIENTATION

REVISIONS

NAE NORTH AMERICAN EXPLORATION, INC.

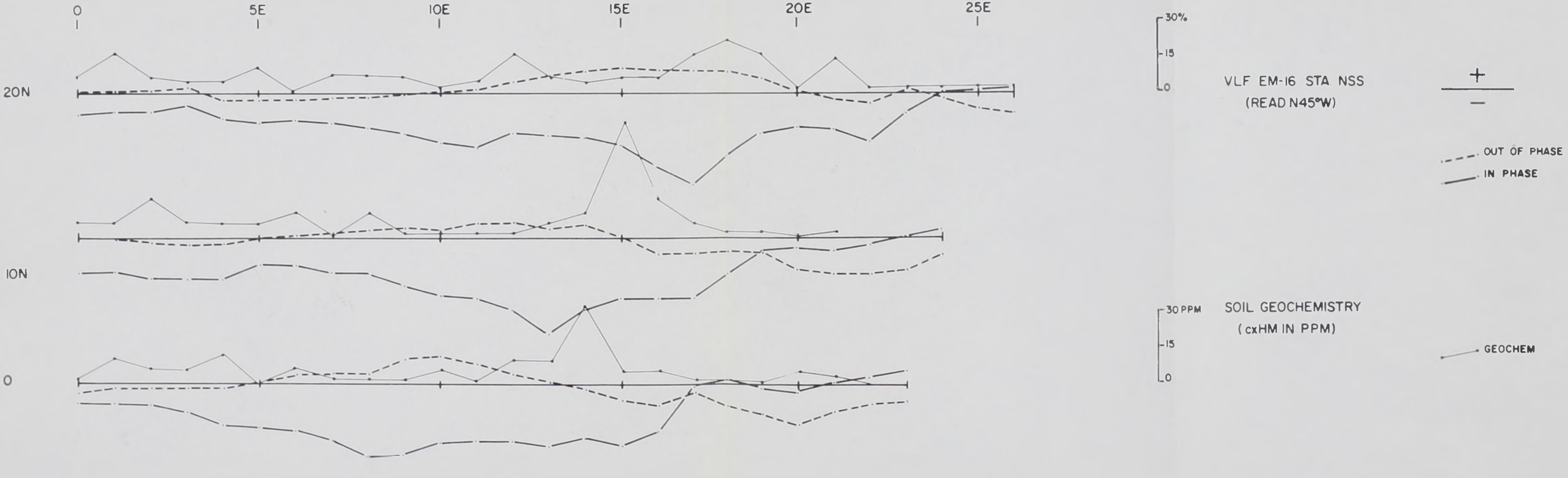
CLIENT: MAINE GEOLOGICAL SURVEY

MAGNETIC VARIATIONS
RECON LINES, AREA "A"

ST. JOHN RIVER PROJECT
AROOSTOOK CO., MAINE

AREA	SCALE	DATE		MAP NO.
9-SJR	1"=1000'	OCT 79	DR. BY: DEP TR. BY: CK. BY: RSY	9-SJR-AMT-001

PLATE C-1



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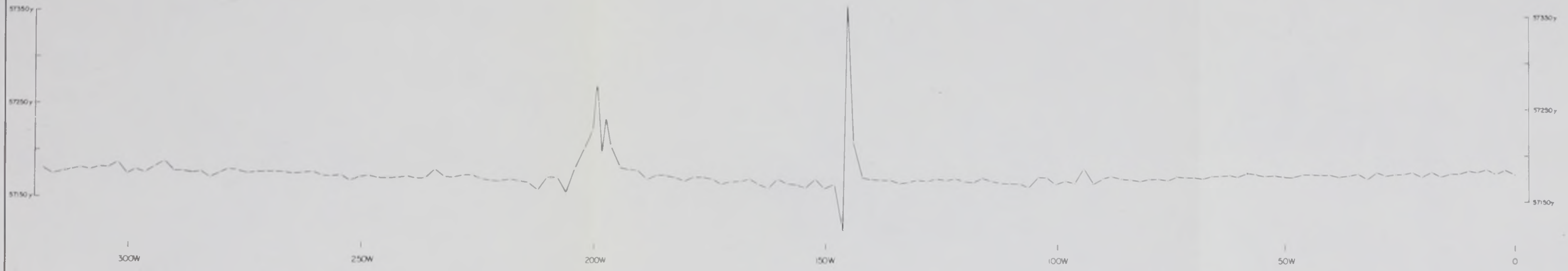
GEOPHYSICAL - GEOCHEMICAL COMPARISON
STATION NSS ONLY
ROCKY MTN GRID, AREA "A"

ST. JOHN RIVER PROJECT
AROOSTOOK CO., MAINE

AREA	SCALE	DATE		MAP NO.
9-SJR	1" = 200'	OCT. 79	DR. BY: DEP TR. BY: DEP CH. BY: RSY	9-SJR-RMG-GC-001

PLATE B-3

MT-6



MT-7

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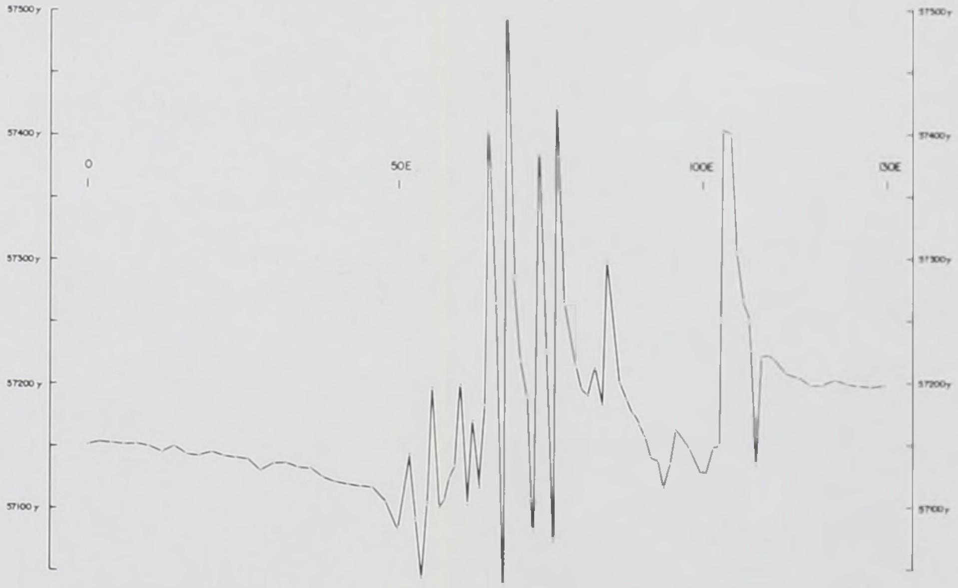
FEET

NOTE:
SEE INDEX MAP FOR LINE
LOCATION AND ORIENTATION

REVISIONS		
BASE	OTHER	NAE NORTH AMERICAN EXPLORATION, INC
		CLIENT MAINE GEOLOGICAL SURVEY
		MAGNETIC VARIATIONS RECON LINES, AREA "C" ST JOHN RIVER PROJECT AROOSTOOK CO., MAINE

AREA	SCALE	DATE	DR BY: DEP TR BY:	MAP NO.

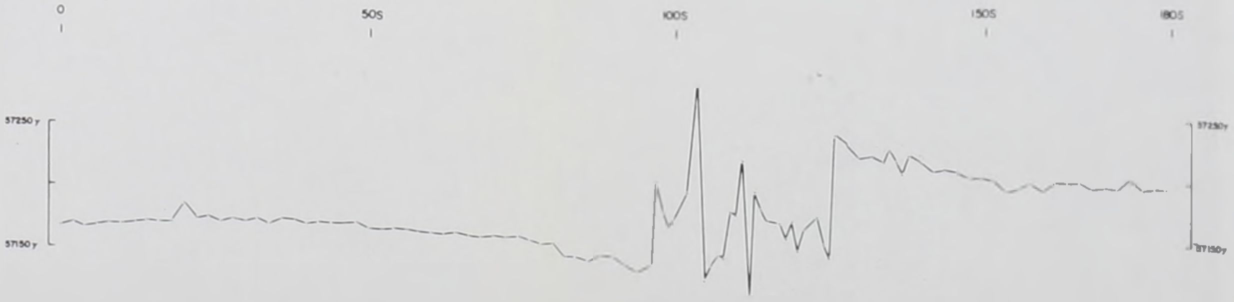
MT-3



MT-5

NOTE

SEE INDEX MAP FOR LINE
LOCATION AND ORIENTATION



MT-4

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FEET

REVISIONS		**NAE** NORTH AMERICAN EXPLORATION, INC
BASE	OTHER	CLIENT: MAINE GEOLOGICAL SURVEY
		MAGNETIC VARIATIONS RECON LINES, AREA "B" ST JOHN RIVER PROJECT AROOSTOOK CO.,MAINE

AREA	SCALE	DATE	DR. BY: DEP TR. BY: CH. BY: RSY	MAP NO.
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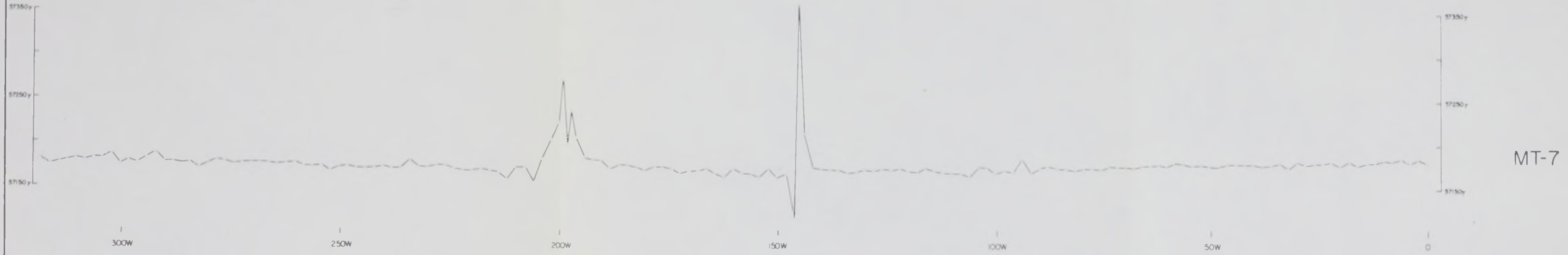

NOTE:

SEE INDEX MAP FOR LINE
LOCATION AND ORIENTATION

REVISIONS
BASE OTHER

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NORTH AMERICAN EXPLORATION, INC
[illegible]

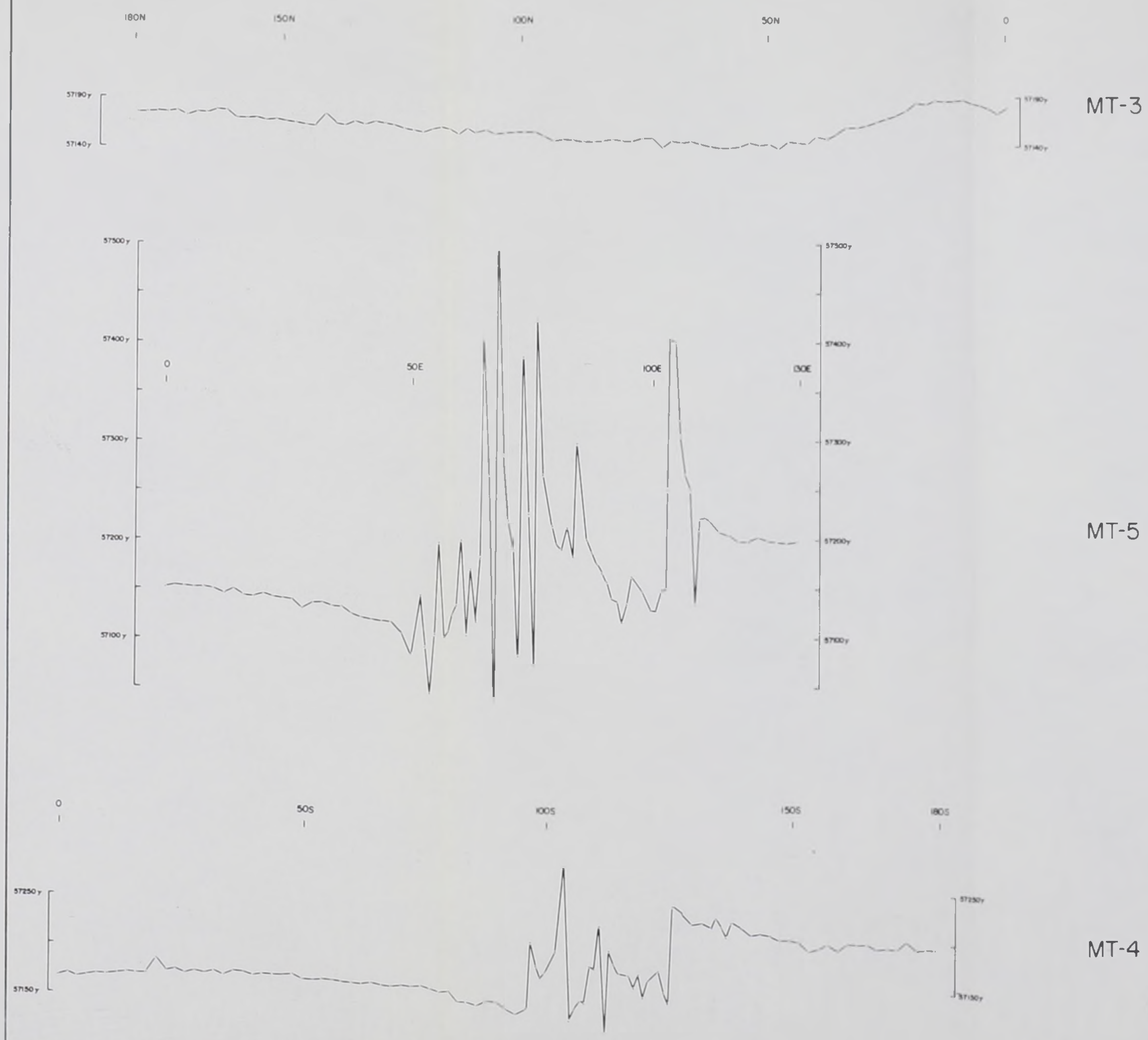
CLIENT: MAINE GEOLOGICAL SURVEY

MAGNETIC VARIATIONS
RECON LINES, AREA "C"

ST JOHN RIVER PROJECT
AROOSTOOK CO., MAINE

AREA	SCALE	DATE		MAP NO.
9-SJR	1"=1000'	OCT 79	DR BY: DEP TR BY: CK BY: RSY	9-SJR-CMT-001

PLATE C-3



NOTE:
SEE INDEX MAP FOR LINE
LOCATION AND ORIENTATION

0 1000 2000
FEET

REVISIONS

NAE NORTH AMERICAN EXPLORATION, INC.

CLIENT: MAINE GEOLOGICAL SURVEY

MAGNETIC VARIATIONS
RECON LINES, AREA "B"

ST JOHN RIVER PROJECT
AROOSTOOK CO.,MAINE

AREA	SCALE	DATE		MAP NO.
9-SJR	1"=1000'	OCT.79	DR. BY: DEF TR. BY: CH. BY: RSY	9-SJR-BMT-001

MINERAL RESOURCE POTENTIAL

UPPER ST. JOHN RIVER VALLEY

STRATIGRAPHIC DESCRIPTIONS

LOCATION			DESCRIPTION	MAP UNIT
J-2		2m	Sand/cobbles	Qgo
J-3	D	2m	Pebble sand/sand/compact till	Qgo
J-4	D	2.5m	Loose sandy till/contorted rk/rk	Qt
J-5	D	1.5m	Pebble sand/fine gravel; imbrication 150°Az 30°S Dip	Qgo
J-6		3m	Sands/clay and silt rythmites	Qgd
J-7	D	3m	Pebble gravel; imbrication 220°Az 30°W Dip	Qg
J-8		3m	Gravel	Qge
J-9		1m	Loose sandy till	Qt
J-10		1m	Loose sandy till	Qt
J-11		1m	Loose sandy till	Qt
J-12			Till	Qt
J-13			Contact till and swamp	Qt/Qs
J-14	D	1.5m	Massive sand/gravel	Qgd
J-15			Till with bedrock blocks	Qt
J-16		4m	Massive boulder gravel	Qge
J-17			Boulder gravel	Qgo
J-18		10m	Medium compact sandy till ridge	Qmt
J-19		1m	Contact, till and gravel; imbrication 90°Az 25°W Dip	Qt/Qg
J-20		2m	Coarse boulder gravel	Qaf
J-21		20m	River exposure of gravel	Qe
J-22		3m	Gravel	Qe
J-23		1.5m	Coarse sand and gravel	Qg
J-24	D	2m	Till	Qt
J-25		1.5m	Till/rk	Qt
J-26	D	1.5m	Compact clayey till	Qt
J-27			Clayey till	Qt
J-28		1m	Sandy till, lt. gray	Qt
J-29		2m	Gravel	Qe
J-30	D	3m	Cobble gravel/bedded fine sands/coarse gravel	Qgd
J-31	D	4m	Coarse gravel/sand-silt/bedded sand/compact silty till	Qal
J-32		2m	Cobble gravel	Qal
J-33	D	1.5m	Compact oxidized sandy till	Qt
J-34			Gravel	Qal
J-34A	D	2m	Poorly sorted, bedded gravel; imbrication 355°Az 15°S Dip	Qgk
J-34B	D		Coarse poorly sorted gravel	Qge
J-35			Boulder gravel, wet	Qs
J-36		1.5m	Medium sand, gravel	Qgk
J-37		2m	Till with included bedrock blocks	Qt
J-38			Contact till and gravel	Qt/Qg
J-39	D	1m	Medium compact sandy till	Qt
J-42		6m	Gravels/rk	Qgo
J-43	D	2.5m	Medium compact sandy till	Qt
J-44		1m	Cobble gravel	Qg
J-45	D	1m	Compact clayey till	Qt
J-46			Till color change due to water table	Qs
J-47		2m	Poorly sorted coarse gravel	Qg
J-48		1.5m	Disturbed medium sand with pebbles/till/rk	Qg
J-49		3m	Very compact weakly calcareous silty till/poorly sorted gravel	Qt
J-50			Planed rk surface	rk
J-51			Red sandstone rk	rk
J-52		4m	Gravel/rk	Qge
J-53		4m	Gravel, sand	Qg
J-54		4m	Gravel (same deposit as J-53)	Qg
J-55		1.5m	Loose silty till	Qt
J-56		.5m	Loose sandy till/disturbed rk	Qt
J-57		1m	Loose diamicton/coarse sand with cobbles	Qsk
J-58			Gravel	Qgo
J-59		2m	Coarse gravel	Qgo
J-60		4m	River terrace	Qal
J-61	D	1.5m	Loose sandy till/weathered rk/rk	Qt
J-62		2m	Coarse gravel/rk	Qmh
J-63			Till/contorted rk/rk	Qmh
J-64			Coarse matrix diamicton	Qmh
J-65	D		Coarse matrix diamicton	Qmh
J-66			Rk exposure	rk
J-67		1m	Till/5m rk	Qt
J-68		2m	Till with included bedrock	Qt
J-69		2m	Cobble, pebble gravel	Qgo
J-70		6m	Boulder gravel; imbrication 45°Az 18°S Dip	Qge
J-71		1m	Till/rk	Qt
J-72	D	22m	Gravels/bedded sands with imbrication parallel to present St. John (NW)/compact gray silty till	Qal
J-73	D	4m	Laminated sand/boulder, pebble gravel/compact calcareous brown-tan clayey-silty till with weathered clasts/compact calcareous gray clayey/silty till	
J-74		10m	Gray till	Qm
J-75		1m	Till/rk	Qt
J-76			Coarse pebble gravel	Qg
J-77	D	5m	Compact calcareous silty till/non-calcareous diamicton/compact calcareous clayey till	Qt
J-78			Brown till, gray till, red till, interfingering relationships	Qt
J-79			Colluvium/cobble gravel	Qt
J-80	D	4m	Compact brown silty till/compact gray silty till	Qt
J-81	D	2m	Cobbles with sand/silts with pebbles/ clay-silt with pebbles	Qal
J-82	D	2m	Compact brown stratified cobble gravel/compact gray silty till	Qal
J-83	D	2m	Compact gray clayey till	Qt
J-84		8m	Slumped till exposure	Qt
J-85	D	5m	Compact brown silty till/compact gray silty till/compact red silty till/contorted silt beds	Qt
J-86	D		Loose brown sandy till	Qm
J-87			Till with incorporated rk	Qt
J-95		2m	Gravel	Qgo
J-96		6m	Sands/slump	Qal
J-97	D	7m	Coarse gravel/gravel with cobbles, sand	Qgd
J-98	D	1.5m	Medium compact till that grades horizontally to gravel units	Qgkt
J-99	D	3m	Poorly sorted coarse gravel	Qgkt
J-100			Gravel	Qgo
J-101			Contact till and gravel	Qt/Qgo
J-102			Poorly sorted gravel	Qg
J-105	D	1m	Clay and silt rythmites	Qal
J-106	D	1m	Silt with wood fragments	Qal
J-107			Massive silt/bedded sands	Qal
J-108	D	4m	Loose oxidized coarse diamicton/vertically bedded boulder gravel, massive sand, clay and silt rythmites	Qal
J-109	D	2m	Bedded sand/clay and silt rythmites	Ql
J-110	D	9m	Contorted sand beds/clay and silt rythmites	Ql
J-111	D	10m	Gray sand beds with gravel/coarse sand beds with pebbles	Qgd
J-111A			6m deep, 20m wide galley	meltwater channel
J-112		4m	Fine sand and boulder gravel; imbrication 225°Az 34°N Dip	Qgd
J-113			Contact gravel and till	Qg/Qt
J-114		6m	Sand-silt/cobble gravel/compact boulder gravel/slump	Ql
J-115	D	12m	Slump/sands clay gradational contact to very compact calcareous clayey till/vertically bedded sands, silts	Ql
J-116	D	4m	Cobble gravel/coarse sand with pebbles	Qg
J-117	D	1.5m	Gravel/sands/clay and silty rythmites/rk	Qal
J-117A	D	2m	Poorly sorted cobble gravel	Qg
J-118			Contact gravel/till	Qg/Qt
J-118A		2m	Till	Qt
J-119		2m	Till with incorporated rk	Qt
J-120	D	4m	Crudely bedded cobble gravel	Qgk
J-121	D	4m	Crudely bedded coarse cobble gravel	Qmh
J-122		2m	Cobble gravel	Qgo
J-122A		2m	Loose graywacke rich till	Qt
J-123		1m	Compact till with varying colors and texture	Qt
J-123A		1m	Loose, coarse till	Qm
J-124		2m	Loose, sandy-silty till/incorporated rk/rk	Qt

STRIATION LIST

S-1	180°T
S-2	155°T, 180°T
S-3	350°Az over 80°T
S-5	330°Az, 340°Az
S-6	358°Az
S-7	350°Az, 102°T
S-9	110°Az over 210°Az
S-10	175°T
S-11	0°Az, 350°Az
S-12	15°T
S-13	104°T, 170°T, 340°Az, others
S-14	330°Az
S-15	337°Az
S-16	338°Az over 4°Az
S-17	350°Az over 100°Az
S-18	15°T, 85°T, 320°Az
S-19	355°Az
S-20	0°Az
S-22	349°Az
S-23	348°Az over 45°T, 85°T, 138°T
S-24	93°T
S-25	342°Az
S-26	0°T
S-27	0°Az, 135°T
S-28	4°Az, 148°T
S-29	163°T
S-31	4°Az
S-32	166°T over 87°T
S-32A	160°T
S-33	175°T
S-33A	115°T
S-33B	5°T
S-34	1°Az, 5°Az
S-35	0°Az
S-36	350°Az
S-37	1°Az, 87°T
S-38	5°T
S-40	1°Az over 90°T
S-40A	78°T
S-41A	100°T
S-42	330°Az, 345°Az
S-43	350°Az over 135°T, 8°T
S-44	153°T over 63°T
S-45	155°T
S-46	95°T, 150°T
S-47	19°T, 147°T over 98°T and 35°T
S-48	100°T
S-49	142°T
S-50	345°Az
S-65	345°Az
S-66	165°T
S-67	340°Az
S-68	15°T over 340°Az
S-69	152° over 115°T
S-70	156°T
S-71	150°T
S-72	104°T over 154°T
S-73	78°T over 339°Az
S-74	152°T
S-75	135°T
S-76	156°T
S-77	16°T
S-78	146°T, 160°T
S-79	335°Az
S-81	127°T over 154°T
S-82	80°T, 133°T

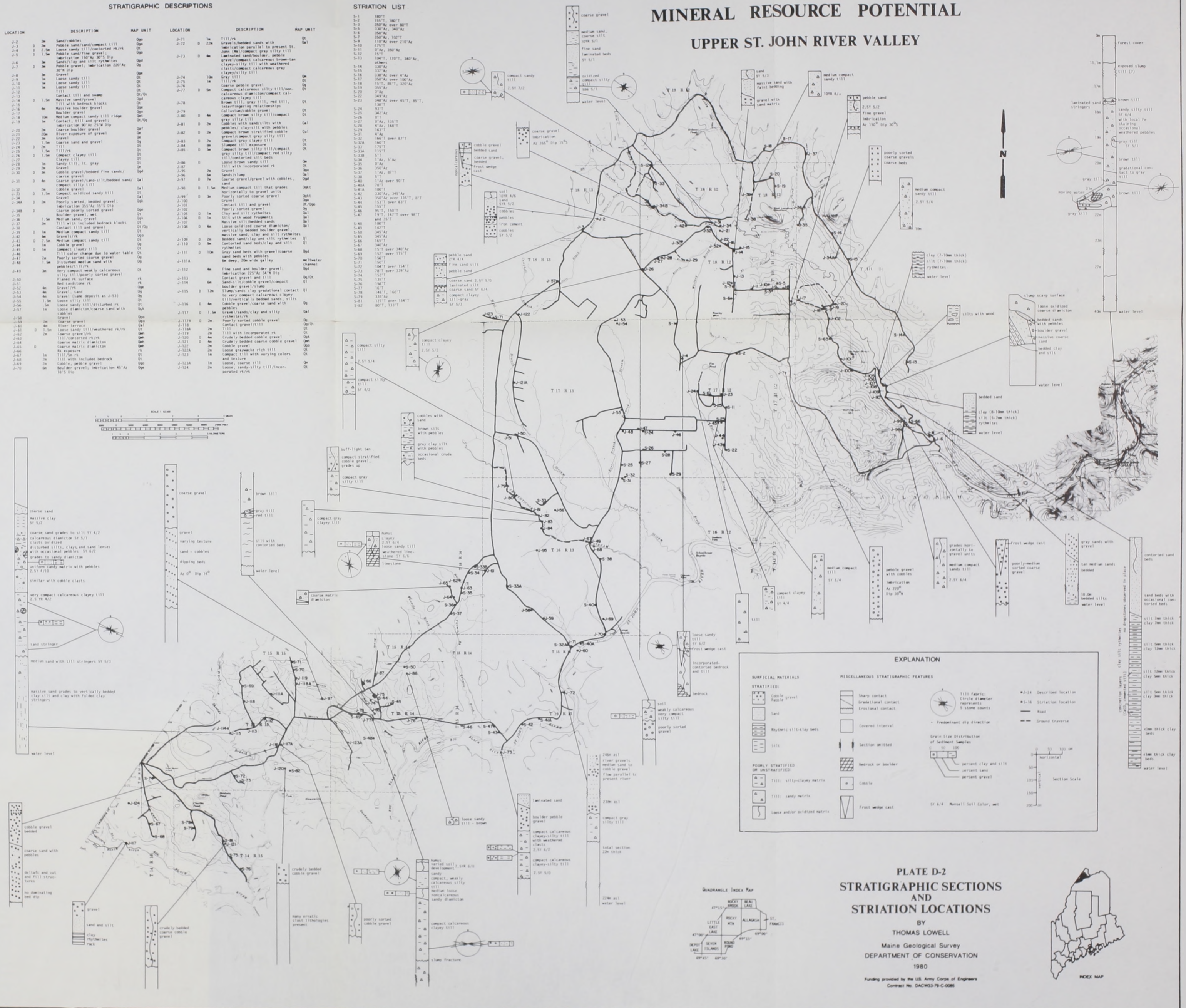


PLATE D-2

STRATIGRAPHIC SECTIONS AND STRIATION LOCATIONS

BY

THOMAS LOWELL

Maine Geological Survey
DEPARTMENT OF CONSERVATION
1980

Funding provided by the U.S. Army Corps of Engineers
Contract No. DACW33-79-C-0085

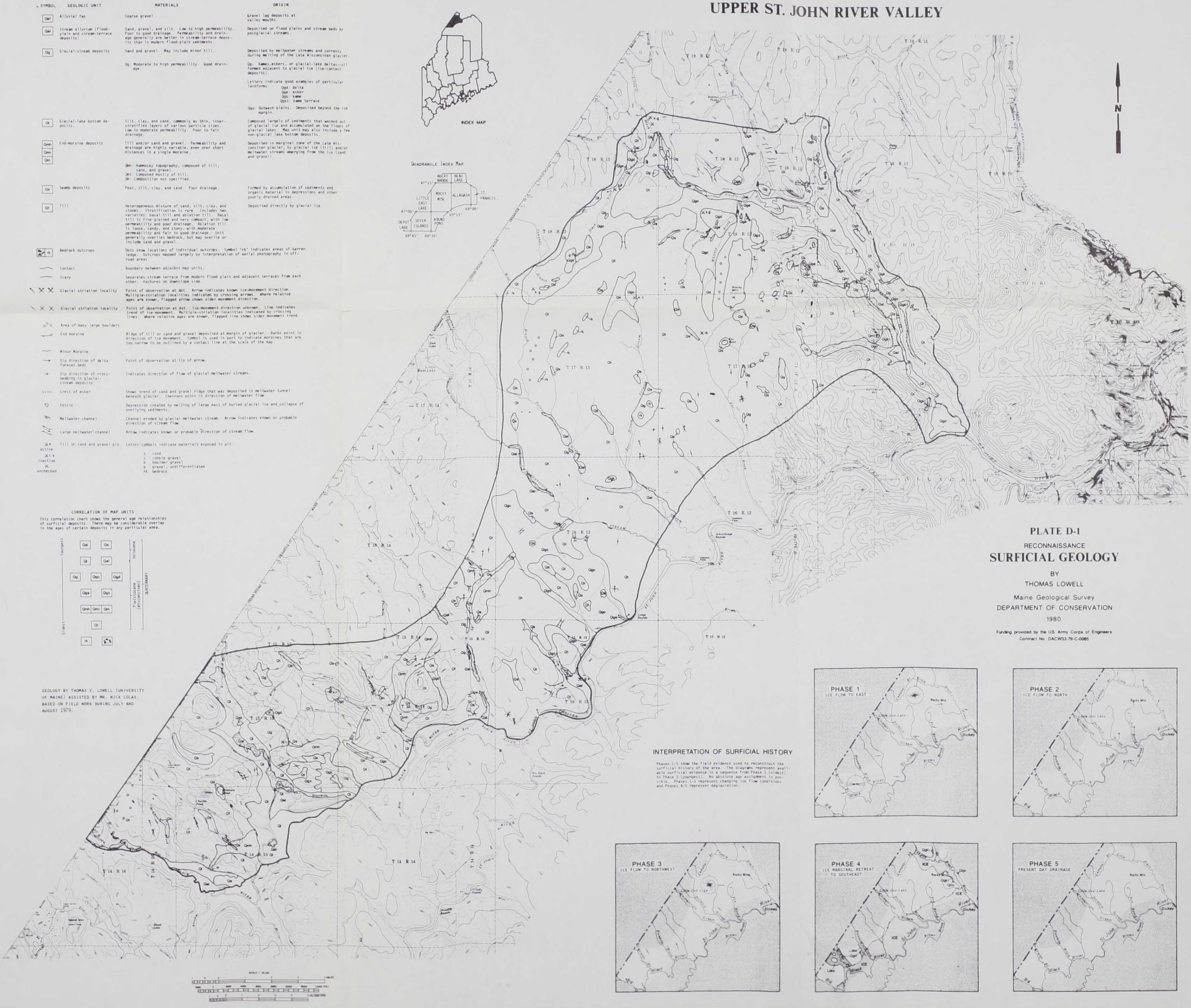
MINERAL RESOURCE POTENTIAL

UPPER ST. JOHN RIVER VALLEY

SYMBOL	GEOLOGIC UNIT	MATERIALS	ORIGIN
Qaf	Alluvial fan	Coarse gravel	Gravel lag deposits at valley mouths.
Qal	Stream alluvium (flood-plain and stream-terrace deposits)	Sand, gravel, and silt. Low to high permeability. Poor to good drainage. Permeability and drainage generally are better in stream-terrace deposits than in modern flood-plain sediments.	Deposited on flood plains and stream beds by postglacial streams.
Qg	Glacial-stream deposits	Sand and gravel. May include minor till. Qg: Moderate to high permeability. Good drainage.	Deposited by meltwater streams and currents during melting of the Late Wisconsinan glacier. Qg: Kames, eskers, or glacial-lake deltas--all formed adjacent to glacial ice (ice-contact deposits). Letters indicate good examples of particular landforms: Qgd: delta Qge: esker Qgk: kame Qgkt: kame terrace Qgo: Outwash plains. Deposited beyond the ice margin.
Ql	Glacial-lake bottom deposits.	Silt, clay, and sand, commonly as thin, interstratified layers of various particle sizes. Low to moderate permeability. Poor to fair drainage.	Composed largely of sediments that washed out of glacial ice and accumulated on the floors of glacial lakes. Map unit may also include a few non-glacial lake bottom deposits.
Qmh Qmt Qm	End-moraine deposits	Till and/or sand and gravel. Permeability and drainage are highly variable, even over short distances in a single moraine. Qmh: Hummocky topography, composed of till, sand, and gravel. Qmt: Composed mostly of till. Qm: Composition not specified.	Deposited in marginal zone of the Late Wisconsinan glacier, by glacial ice (till) and/or meltwater streams emerging from the ice (sand and gravel).
Qs	Swamp deposits	Peat, silt, clay, and sand. Poor drainage.	Formed by accumulation of sediments and organic material in depressions and other poorly drained areas.
Qt	Till	Heterogeneous mixture of sand, silt, clay, and stones. Stratification is rare. Includes two varieties: basal till and ablation till. Basal till is fine grained and very compact, with low permeability and poor drainage. Ablation till is loose, sandy, and stony, with moderate permeability and fair to good drainage. Unit generally overlies bedrock, but may overlie or include sand and gravel.	Deposited directly by glacial ice.
rk	Bedrock outcrops	Dots show locations of individual outcrops. Symbol "rk" indicates areas of barren ledge. Outcrops mapped largely by interpretation of aerial photography in off-road areas.	
⌒	Contact	Boundary between adjacent map units.	
—	Scarp	Separates stream terrace from modern flood plain and adjacent terraces from each other. Hachures on downslope side.	
↖ ✕ ✕	Glacial striation locality	Point of observation at dot. Arrow indicates known ice-movement direction. Multiple-striation localities indicated by crossing arrows. Where relative ages are known, flagged arrow shows older movement direction.	
∖ ✕ ✕	Glacial striation locality	Point of observation at dot. Ice-movement direction unknown. Line indicates trend of ice movement. Multiple-striation localities indicated by crossing lines. Where relative ages are known, flagged line shows older movement trend.	
∘°∘	Area of many large boulders		
⌣	End moraine	Ridge of till or sand and gravel deposited at margin of glacier. Barbs point in direction of ice movement. Symbol is used in part to indicate moraines that are too narrow to be outlined by a contact line at the scale of the map.	
∼	Minor Moraine		
→	Dip direction of delta foreset beds	Point of observation at tip of arrow.	
→	Dip direction of cross-bedding in glacial-stream deposits	Indicates direction of flow of glacial meltwater streams.	
>>>>	Crest of esker	Shows trend of sand and gravel ridge that was deposited in meltwater tunnel beneath glacier. Chevrons point in direction of meltwater flow.	
♡	Kettle	Depression created by melting of large mass of buried glacial ice and collapse of overlying sediments.	
⇝	Meltwater channel	Channel eroded by glacial meltwater stream. Arrow indicates known or probable direction of stream flow.	
⇉	Large meltwater channel	Arrow indicates known or probable direction of stream flow.	
✕s active ✕c,s inactive ✕ unchecked	Till or sand and gravel pit	Letter symbols indicate materials exposed in pit: s sand c cobble gravel b boulder gravel g gravel, undifferentiated rk bedrock	

CORRELATION OF MAP UNITS

This correlation chart shows the general age relationships of surficial deposits. There may be considerable overlap in the ages of certain deposits in any particular area.



GEOLOGY BY THOMAS V. LOWELL (UNIVERSITY OF MAINE) ASSISTED BY MR. NICK COLAS. BASED ON FIELD WORK DURING JULY AND AUGUST 1979.

PLATE D-1

RECONNAISSANCE

SURFICIAL GEOLOGY

BY

THOMAS LOWELL

Maine Geological Survey
DEPARTMENT OF CONSERVATION
1980

Funding provided by the U.S. Army Corps of Engineers
Contract No. DACW33-79-C-0085

INTERPRETATION OF SURFICIAL HISTORY

Phases 1-5 show the field evidence used to reconstruct the surficial history of the area. The diagrams represent available surficial evidence in a sequence from Phase 1 (oldest) to Phase 5 (youngest). No absolute age assignment is possible. Phases 1-3 represent changing ice flow conditions and Phases 4-5 represent deglaciation.

MINERAL RESOURCE POTENTIAL

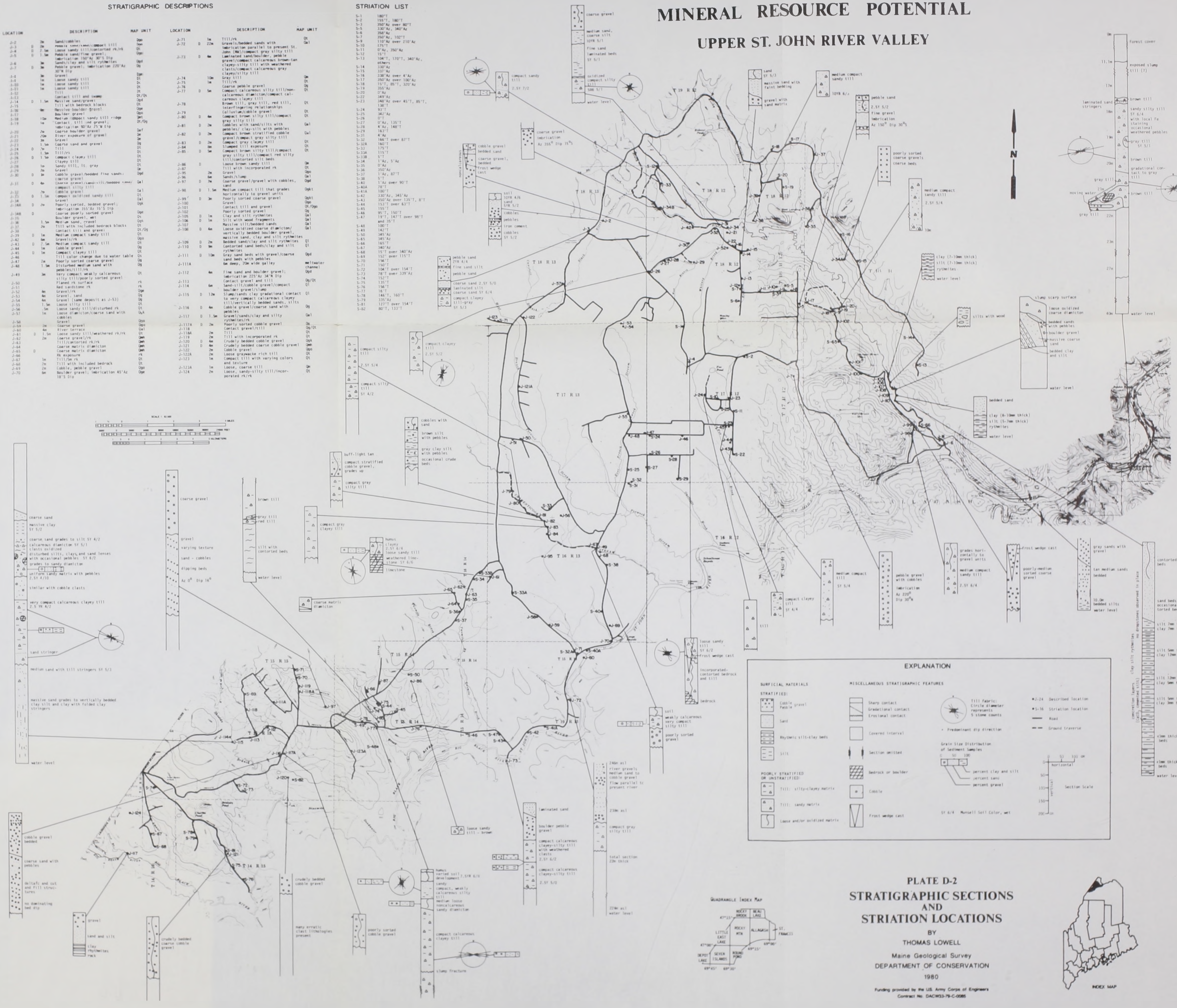
UPPER ST. JOHN RIVER VALLEY

STRATIGRAPHIC DESCRIPTIONS

LOCATION			DESCRIPTION	MAP UNIT
J-2		2m	Sand/cobbles	Qgo
J-3	D	2m	Pebble sand/sand/compact till	Qgo
J-4	D	2.5m	Loose sandy till/contorted rk/rk	Qt
J-5	D	1.5m	Pebble sand/fine gravel; imbrication 150°Az 30°S Dip	Qgm
J-6		3m	Sands/clay and silt rythmites	Qgd
J-7	D	3m	Pebble gravel; imbrication 220°Az 30°N Dip	Qg
J-8		3m	Gravel	Qgm
J-9		1m	Loose sandy till	Qt
J-10		1m	Loose sandy till	Qt
J-11		1m	Loose sandy till	Qt
J-12			Till	Qt
J-13			Contact till and swamp	Qt/Qs
J-14	D	1.5m	Massive sand/gravel	Qgd
J-15			Till with bedrock blocks	Qt
J-16		4m	Massive boulder gravel	Qge
J-17			Boulder gravel	Qgo
J-18		10m	Medium compact sandy till ridge	Qmt
J-19		1m	Contact, till and gravel, imbrication 90°Az 25°W Dip	Qt/Qg
J-20		2m	Coarse boulder gravel	Qaf
J-21		20m	River exposure of gravel	Qe
J-22		3m	Gravel	Qe
J-23		1.5m	Coarse sand and gravel	Qg
J-24	D	.5m	Till	Qt
J-25		1.5m	Till/rk	Qt
J-26	D	1.5m	Compact clayey till	Qt
J-27			Clayey till	Qt
J-28		1m	Sandy till, lt. gray	Qt
J-29		2m	Gravel	Qe
J-30	D	3m	Cobble gravel/bedded fine sands/coarse gravel	Qgd
J-31	D	4m	Coarse gravel/sand-silt/bedded sand/compact silty till	Qal
J-32		2m	Cobble gravel	Qal
J-33	D	1.5m	Compact oxidized sandy till	Qt
J-34			Gravel	Qal
J-34A	D	2m	Poorly sorted, bedded gravel; imbrication 355°Az 15°S Dip	Qgk
J-34B	D		Coarse poorly sorted gravel	Qge
J-35			Boulder gravel, wet	Qs
J-36		1.5m	Medium sand, gravel	Qgk
J-37		2m	Till with included bedrock blocks	Qt
J-38			Contact till and gravel	Qt/Qg
J-39	D	1m	Medium compact sandy till	Qt
J-42		6m	Gravels/rk	Qgo
J-43	D	2.5m	Medium compact sandy till	Qt
J-44		1m	Cobble gravel	Qg
J-45	D	1m	Compact clayey till	Qt
J-46			Till color change due to water table	Qs
J-47		2m	Poorly sorted coarse gravel	Qg
J-48		1.5m	Disturbed medium sand with pebbles/till/rk	Qg
J-49		3m	Very compact weakly calcareous silty till/poorly sorted gravel	Qt
J-50			Planed rk surface	rk
J-51			Red sandstone rk	rk
J-52		4m	Gravel/rk	Qge
J-53		4m	Gravel, sand	Qg
J-54		4m	Gravel (same deposit as J-53)	Qg
J-55		1.5m	Loose silty till	Qt
J-56		.5m	Loose sandy till/disturbed rk	Qt
J-57		1m	Loose diamicton/coarse sand with cobbles	Qgk
J-58			Gravel	Qgo
J-59		2m	Coarse gravel	Qgo
J-60		4m	River terrace	Qal
J-61	D	1.5m	Loose sandy till/weathered rk/rk	Qt
J-62		2m	Coarse gravel/rk	Qmh
J-63			Till/contorted rk/rk	Qmh
J-64			Coarse matrix diamicton	Qmh
J-65	D		Coarse matrix diamicton	Qmh
J-66			Rk exposure	rk
J-67		1m	Till/5m rk	Qt
J-68		2m	Till with included bedrock	Qt
J-69		2m	Cobble, pebble gravel	Qgo
J-70		6m	Boulder gravel; imbrication 45°Az 18°S Dip	Qge
J-71		1m	Till/rk	Qt
J-72	D	22m	Gravels/bedded sands with imbrication parallel to present St. John (NW)/compact gray silty till	Qal
J-73	D	4m	Laminated sand/boulder, pebble gravel/compact calcareous brown-tan clayey-silty till with weathered clasts/compact calcareous gray clayey/silty till	
J-74		10m	Gray till	Qm
J-75		1m	Till/rk	Qt
J-76			Coarse pebble gravel	Qg
J-77	D	5m	Compact calcareous silty till/non-calcareous diamicton/compact calcareous clayey till	Qt
J-78			Brown till, gray till, red till, interfingering relationships	Qt
J-79			Colluvium/cobble gravel	Qt
J-80	D	4m	Compact brown silty till/compact gray silty till	Qt
J-81	D	2m	Cobbles with sand/silts with pebbles/ clay-silt with pebbles	Qal
J-82	D	2m	Compact brown stratified cobble gravel/compact gray silty till	Qal
J-83	D	2m	Compact gray clayey till	Qt
J-84		8m	Slumped till exposure	Qt
J-85	D	5m	Compact brown silty till/compact gray silty till/compact red silty till/contorted silt beds	Qt
J-86	D		Loose brown sandy till	Qm
J-87			Till with incorporated rk	Qt
J-95		2m	Gravel	Qgo
J-96		6m	Sands/slump	Qal
J-97	D	7m	Coarse gravel/gravel with cobbles, sand	Qgd
J-98	D	1.5m	Medium compact till that grades horizontally to gravel units	Qgkt
J-99	D	3m	Poorly sorted coarse gravel	Qgkt
J-100			Gravel	Qgo
J-101			Contact till and gravel	Qt/Qgo
J-102			Poorly sorted gravel	Qg
J-105	D	1m	Clay and silt rythmites	Qal
J-106	D	1m	Silt with wood fragments	Qal
J-107			Massive silt/bedded sands	Qal
J-108	D	4m	Loose oxidized coarse diamicton/vertically bedded boulder gravel, massive sand, clay and silt rythmites	Qal
J-109	D	2m	Bedded sand/clay and silt rythmites	Ql
J-110	D	9m	Contorted sand beds/clay and silt rythmites	Ql
J-111	D	10m	Gray sand beds with gravel/coarse sand beds with pebbles	Qgd
J-111A			6m deep, 20m wide galley	meltwater channel
J-112		4m	Fine sand and boulder gravel; imbrication 225°Az 34°N Dip	Qgd
J-113			Contact gravel and till	Qg/Qt
J-114		6m	Sand-silt/cobble gravel/compact boulder gravel/slump	Ql
J-115	D	12m	Slump/sands clay gradational contact to very compact calcareous clayey till/vertically bedded sands, silts	Ql
J-116	D	4m	Cobble gravel/coarse sand with pebbles	Qg
J-117	D	1.5m	Gravel/sands/clay and silty rythmites/rk	Qal
J-117A	D	2m	Poorly sorted cobble gravel	Qg
J-118			Contact gravel/till	Qg/Qt
J-118A		2m	Till	Qt
J-119		2m	Till with incorporated rk	Qt
J-120	D	4m	Crudely bedded cobble gravel	Qgk
J-121	D	4m	Crudely bedded coarse cobble gravel	Qmh
J-122		2m	Cobble gravel	Qgo
J-122A		2m	Loose graywacke rich till	Qt
J-123		1m	Compact till with varying colors and texture	Qt
J-123A		1m	Loose, coarse till	Qm
J-124		2m	Loose, sandy-silty till/incorporated rk/rk	Qt

STRIATION LIST

S-1	180°T
S-2	155°T, 180°T
S-3	350°Az over 80°T
S-5	330°Az, 340°Az
S-6	358°Az
S-7	350°Az, 102°T
S-9	110°Az over 210°Az
S-10	175°T
S-11	0°Az, 350°Az
S-12	15°T
S-13	104°T, 170°T, 340°Az, others
S-14	330°Az
S-15	337°Az
S-16	338°Az over 4°Az
S-17	350°Az over 100°Az
S-18	15°T, 85°T, 320°Az
S-19	355°Az
S-20	0°Az
S-22	349°Az
S-23	348°Az over 45°T, 85°T, 138°T
S-24	93°T
S-25	342°Az
S-26	0°T
S-27	0°Az, 135°T
S-28	4°Az, 148°T
S-29	163°T
S-31	4°Az
S-32	166°T over 87°T
S-32A	160°T
S-33	175°T
S-33A	115°T
S-33B	5°T
S-34	1°Az, 5°Az
S-35	0°Az
S-36	350°Az
S-37	1°Az, 87°T
S-38	5°T
S-40	1°Az over 90°T
S-40A	78°T
S-41A	100°T
S-42	330°Az, 345°Az
S-43	350°Az over 135°T, 8°T
S-44	153°T over 63°T
S-45	155°T
S-46	95°T, 150°T
S-47	19°T, 147°T over 98°T and 35°T
S-48	100°T
S-49	142°T
S-50	345°Az
S-65	345°Az
S-66	165°T
S-67	340°Az
S-68	15°T over 340°Az
S-69	152° over 115°T
S-70	156°T
S-71	150°T
S-72	104°T over 154°T
S-73	78°T over 339°Az
S-74	152°T
S-75	135°T
S-76	156°T
S-77	16°T
S-78	146°T, 160°T
S-79	335°Az
S-81	127°T over 154°T
S-82	80°T, 133°T



EXPLANATION

SURFICIAL MATERIALS

STRATIFIED:

- Cobble / Pebble gravel
- Sand
- Rhythmic silt-clay beds
- Silt

POORLY STRATIFIED OR UNSTRATIFIED:

- Till: silty-clayey matrix
- Till: sandy matrix
- Loose and/or oxidized matrix

MISCELLANEOUS STRATIGRAPHIC FEATURES

- Sharp contact
- Gradational contact
- Erosional contact
- Covered interval
- Section omitted
- Bedrock or boulder
- Cobble
- Frost wedge cast

Till fabric: Circle diameter represents 5 stone counts

• Predominant dip direction

Grain Size Distribution of Sediment Samples

0 50 100

- percent clay and silt
- percent sand
- percent gravel

5Y 6/4 Munsell Soil Color, wet

•J-24 Described location

•S-16 Striation location

— Road

-- Ground traverse

Section Scale: 0, 50, 100, 150, 200 (vertical); 0, 50, 100 (horizontal)

PLATE D-2

STRATIGRAPHIC SECTIONS AND STRIATION LOCATIONS

BY

THOMAS LOWELL

Maine Geological Survey
DEPARTMENT OF CONSERVATION
1980

Funding provided by the U.S. Army Corps of Engineers
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MINERAL RESOURCE POTENTIAL

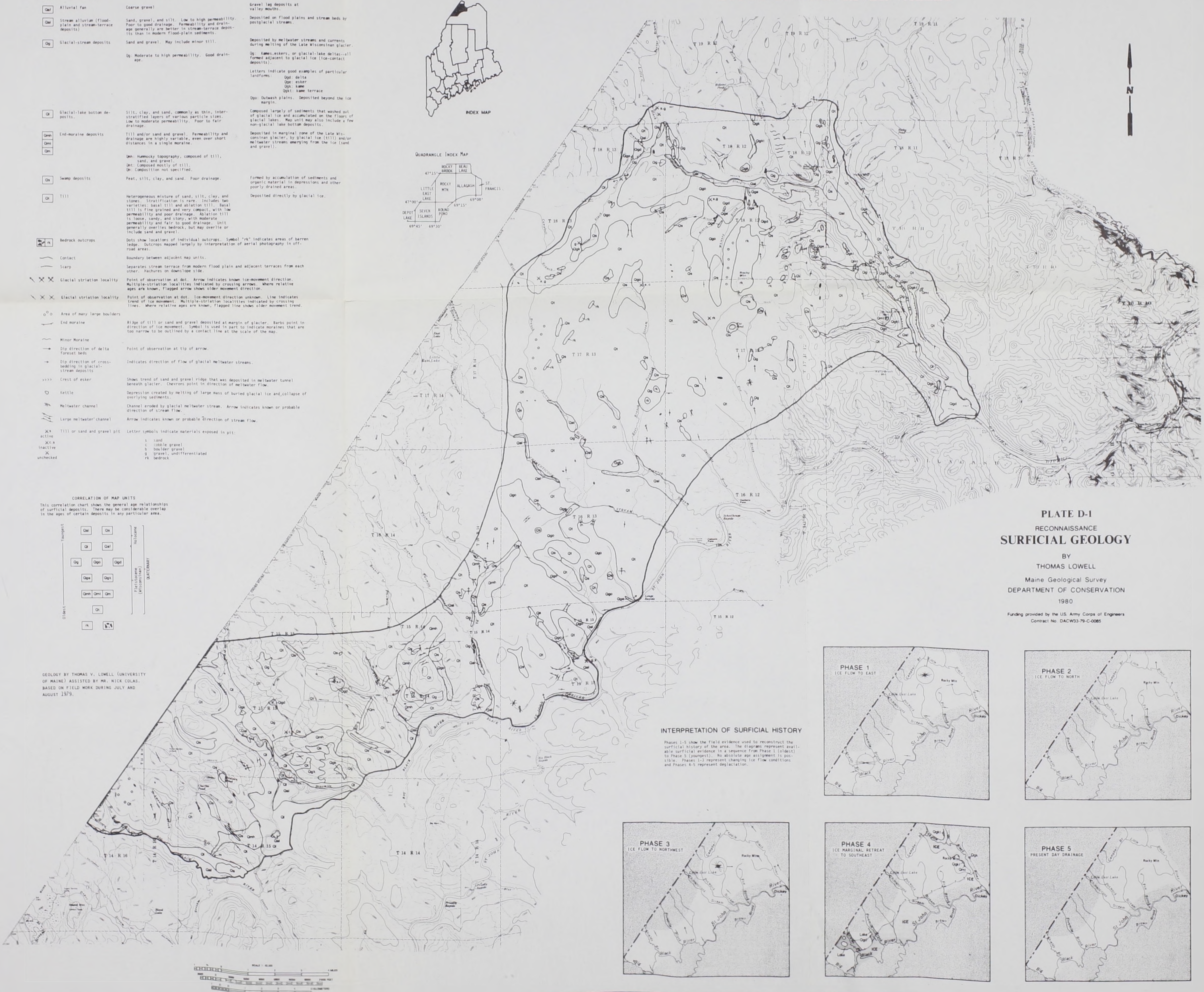
UPPER ST. JOHN RIVER VALLEY

SYMBOL	GEOLOGIC UNIT	MATERIALS	ORIGIN
Qaf	Alluvial fan	Coarse gravel	Gravel lag deposits at valley mouths.
Qal	Stream alluvium (flood-plain and stream-terrace deposits)	Sand, gravel, and silt. Low to high permeability. Poor to good drainage. Permeability and drainage generally are better in stream-terrace deposits than in modern flood-plain sediments.	Deposited on flood plains and stream beds by postglacial streams.
Qg	Glacial-stream deposits	Sand and gravel. May include minor till. Qg: Moderate to high permeability. Good drainage.	Deposited by meltwater streams and currents during melting of the Late Wisconsinan glacier. Qg: Kames, eskers, or glacial-lake deltas--all formed adjacent to glacial ice (ice-contact deposits). Letters indicate good examples of particular landforms: Qgd: delta; Qge: esker; Qgk: kame; Qgkt: kame terrace Qgo: Outwash plains. Deposited beyond the ice margin.
Ql	Glacial-lake bottom deposits.	Silt, clay, and sand, commonly as thin, interstratified layers of various particle sizes. Low to moderate permeability. Poor to fair drainage.	Composed largely of sediments that washed out of glacial ice and accumulated on the floors of glacial lakes. Map unit may also include a few non-glacial lake bottom deposits.
Qmh Qmt Qm	End-moraine deposits	Till and/or sand and gravel. Permeability and drainage are highly variable, even over short distances in a single moraine. Qmh: Hummocky topography, composed of till, sand, and gravel. Qmt: Composed mostly of till. Qm: Composition not specified.	Deposited in marginal zone of the Late Wisconsinan glacier, by glacial ice (till) and/or meltwater streams emerging from the ice (sand and gravel).
Qs	Swamp deposits	Peat, silt, clay, and sand. Poor drainage.	Formed by accumulation of sediments and organic material in depressions and other poorly drained areas.
Qt	Till	Heterogeneous mixture of sand, silt, clay, and stones. Stratification is rare. Includes two varieties: basal till and ablation till. Basal till is fine grained and very compact, with low permeability and poor drainage. Ablation till is loose, sandy, and stony, with moderate permeability and fair to good drainage. Unit generally overlies bedrock, but may overlie or include sand and gravel.	Deposited directly by glacial ice.

rk	Bedrock outcrops	Dots show locations of individual outcrops. Symbol "rk" indicates areas of barren ledge. Outcrops mapped largely by interpretation of aerial photography in off-road areas.
	Contact	Boundary between adjacent map units.
	Scarp	Separates stream terrace from modern flood plain and adjacent terraces from each other. Hachures on downslope side.
	Glacial striation locality	Point of observation at dot. Arrow indicates known ice-movement direction. Multiple-striation localities indicated by crossing arrows. Where relative ages are known, flagged arrow shows older movement direction.
	Glacial striation locality	Point of observation at dot. Ice-movement direction unknown. Line indicates trend of ice movement. Multiple-striation localities indicated by crossing lines. Where relative ages are known, flagged line shows older movement trend.
o°o	Area of many large boulders	
	End moraine	Ridge of till or sand and gravel deposited at margin of glacier. Barbs point in direction of ice movement. Symbol is used in part to indicate moraines that are too narrow to be outlined by a contact line at the scale of the map.
	Minor Moraine	
→	Dip direction of delta foreset beds	Point of observation at tip of arrow.
→	Dip direction of cross-bedding in glacial-stream deposits	Indicates direction of flow of glacial meltwater streams.
>>>>	Crest of esker	Shows trend of sand and gravel ridge that was deposited in meltwater tunnel beneath glacier. Chevrons point in direction of meltwater flow.
	Kettle	Depression created by melting of large mass of buried glacial ice and collapse of overlying sediments.
	Meltwater channel	Channel eroded by glacial meltwater stream. Arrow indicates known or probable direction of stream flow.
	Large meltwater channel	Arrow indicates known or probable direction of stream flow.
×s active ×c,s inactive × unchecked	Till or sand and gravel pit	Letter symbols indicate materials exposed in pit: s sand c cobble gravel b boulder gravel g gravel, undifferentiated rk bedrock

CORRELATION OF MAP UNITS

This correlation chart shows the general age relationships of surficial deposits. There may be considerable overlap in the ages of certain deposits in any particular area.



GEOLOGY BY THOMAS V. LOWELL (UNIVERSITY OF MAINE) ASSISTED BY MR. NICK COLAS. BASED ON FIELD WORK DURING JULY AND AUGUST 1979.

PLATE D-1

RECONNAISSANCE
SURFICIAL GEOLOGY

BY
THOMAS LOWELL

Maine Geological Survey
DEPARTMENT OF CONSERVATION
1980

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INTERPRETATION OF SURFICIAL HISTORY

Phases 1-5 show the field evidence used to reconstruct the surficial history of the area. The diagrams represent available surficial evidence in a sequence from Phase 1 (oldest) to Phase 5 (youngest). No absolute age assignment is possible. Phases 1-3 represent changing ice flow conditions and Phases 4-5 represent deglaciation.

[redacted]